Reef Construction

Biological Monitoring

Public Information

Diving

Fishing

Artificial Reef Management Plan for New Jersey

DRAFT FOR REVIEW

Habitat Fabrication

Reef Structure Preparation and Cleaning

Fund Raising

Reef Site Selection

Reef Permitting

Marine Habitat Enhancement

State of New Jersey
Department of Environmental Protection
Fish & Wildlife

DRAFT FOR REVIEW

ARTIFICIAL REEF MANAGEMENT PLAN FOR NEW JERSEY

September, 2004

James E. McGreevey, Governor
State of New Jersey

Bradley M. Campbell, Commissioner
Department of Environmental Protection

John S. Watson, Jr., Assistant Commissioner
Natural & Historic Resources

Martin J. McHugh, Director
Fish & Wildlife Division

Marine Fisheries Council:
Gilbert Ewing, Jr., Chairman

Dr. Robert B. Abel	**Richard Herb**
Erling Berg	**Nancy Sittineri**
Joseph Rizzo	**Dr. Patrick Donnelly**
Edward Goldman	**John Maxwell**
Francis Puskas	

Prepared By: **Bill Figley**
Principal Fisheries Biologist

New Jersey's Reef Program is partially funded by the Federal Sport Fish Restoration Program.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

The initial draft of the New Jersey Reef Plan was prepared by Dewitt and Evelyn Myatt in 1987, contractors to NJ Department of Environmental Protection. The revised plan was prepared by Bill Figley, Principal Fisheries Biologist, NJ DEP, Fish and Wildlife Division. The report was reviewed by DEP Fish and Wildlife Staff including Tom McCloy, Bruce Freeman, John Makai, Bruce Halgren and Peter Himchak. Typing was performed by Peggy Andrews, Maria Peter, Heather Lee, and Kathy Smallwood. Graphics were prepared by Barry Preim.

DEP is grateful to the following people and organizations that critically reviewed and provided comments regarding this Reef Plan:

Dick Herb, New Jersey Marine Fisheries Council
Pat Donnelly, New Jersey Marine Fisheries Council

A Message From The Commissioner

When the Department of Environmental Protection (DEP) initiated its ocean Reef Program in 1984, no one envisioned that we could accomplish so much and receive so much support from the public. Over the past 19 years, DEP has established a network of 14 ocean reef sites, stretching from Sandy Hook to Cape May, and constructed over 2,200 patch reefs. Studies show that reef structures support a diverse marine life community, hundreds of times more productive than the surrounding sandy sea floor. Nearly, 20 percent of the State's recreational catch of saltwater fish are now taken on reef sites. Governor McGreevey is committed to enhancing New Jersey's aquatic environment - the Reef Program is accomplishing just that.

The success of the Reef Program goes far beyond the DEP and is largely due to the collective contributions of numerous fishing, diving and environmental organizations and corporations and individuals. I see the DEP's role in the Reef Program as that of coordinator and facilitator; working closely with various federal, state and county government agencies to permit reef sites, develop standards for reef materials, build reefs and manage reef resources; overseeing and directing the activities of private industry in reef-building projects and conferring with user groups to better design and develop ocean and reefs.

The Reef Management Plan was prepared to provide the public with a working knowledge of the DEP's Reef Program, including objectives, history, benefits, site selection, permitting, design, material selection and preparation, construction methods, risks, physical, biological and socio-economic monitoring, funding, public information, fisheries management and regulatory requirements. This comprehensive document will guide the DEP's Reef Program for the next 20 years to develop the greatest benefit possible to both the marine life and citizens of New Jersey. In addition, through Directive 2003-02, I established a Technical Reef Advisory Committee, which is composed of marine scientists and reef experts, to independently monitor and evaluate reef materials to further assure that our ocean reefs are effective in meeting their physical and biological expectations.

Bradley M. Campbell,
Commissioner

EXECUTIVE SUMMARY

Artificial reefs have been constructed worldwide to enhance marine life communities and their associated fisheries. Although attempts to build ocean reefs off New Jersey began in 1935, the initial efforts of private groups, organized by party and charter boat captains and fishing clubs, were minimal in extent. In 1984, the State of New Jersey initiated a Reef Program which is administered by the Department of Environmental Protection's (DEP) Division of Fish & Wildlife (F & W). DEP took over three permits issued to private reef-building organizations, selected additional reef sites, obtained federal and state permits and now has a network of 14 artificial reef sites. The reef sites encompass a total of 25 square miles of sea floor and extend from Sandy Hook to Cape May, providing accessibility to anglers and divers from every one of the state's ocean inlets. Private groups are no longer directly involved in constructing reefs; DEP now holds all of the permits for ocean reefs off New Jersey and is the sole entity building reefs.

In 1987, F & W prepared and published an Artificial Reef Plan, which outlined the objectives of the Reef Program and provided guidelines for selecting reef sites and materials and building, monitoring and managing reefs. The current plan supercedes the original and incorporates the experiences gained from over 15 years of reef-building efforts.

The objectives of New Jersey's Reef Program are to:

1) construct hard substrate reef habitat for marine fish, crustaceans and encrusting organisms;

2) provide spawning, nursery, refuge and feeding area for marine life;

3) increase diversity and abundance of marine life;

4) create fishing grounds for hook and line fishermen;

5) provide underwater structures for scuba divers;

6) provide economic benefits to recreational fishing industries.

While trying to meet the objectives of the Reef Program, DEP's

underlying goal in both constructing and managing reefs is to spread the benefits of the reefs among as many people as possible. The intent of the program is not to change New Jersey's marine environment, but rather to enhance a small portion (less than 1 percent) of the State's sea floor to benefit about 150 species of fish and other marine life that prefers structured, reef habitat. The benefited species are endemic to New Jersey waters, but limited in extent and abundance by the lack of hard-substrate habitat. The objectives and goal of the Reef Program are aligned with the Mission and Strategic Goal of a Healthy Ecosystem in DEP's Strategic Plan.

Since 1984, over 1,800 patch reefs have been constructed from rock, concrete rubble, ships and barges, army tanks, concrete-ballasted tire units and designed concrete structures. Guidelines have been established for selecting, inspecting and deploying reef materials. Monitoring reef structures in the ocean has provided insight into the stability and durability of reef materials and consequently, has enabled DEP to develop a list of acceptable reef materials. Biological assessments have demonstrated the productivity of marine life communities on reef habitats. Socio-economic surveys have provided information concerning the participation, effort, catch and economic value of reef fisheries. This plan outlines future reef monitoring surveys. An array of information is needed to both assess the effectiveness of reef-building efforts in meeting program objectives and manage reef resources among the various user groups. To meet the goal of the Reef Program, DEP may have to restrict or discourage uses of reefs that allow a small group of people to dominate either reef resources or access to those resources. This may require petitioning the Mid-Atlantic Fishery Management Council to designate reefs as Special Management Zones, where fishing gear can be restricted.

Since the inception of the State's reef program, recreational fishing and diving activities on reef sites have grown dramatically accounting for 90 percent of the private and 46 percent of the party boat bottom fishing effort and 62 percent of the private boat diving activity in 2000. Recreational anglers strongly support the program; their primary suggestions are to build more reefs and closer to shore. To provide the public with information regarding the Reef Program, F & W publishes an annual newsletter, has an internet website, publishes reef charts and has helped prepare several television documentaries.

ARTIFICIAL REEF MANAGEMENT PLAN FOR NEW JERSEY

At its publication in 1987, the New Jersey Reef Plan was intended to be a starting point and working document that would be amended and updated as necessary to keep pace with current technology and research. The goals of New Jersey's first update are to modify the initial plan to reflect experience gained from 17 years of reef construction, monitoring and management. It should be noted that the National Artificial Reef Plan is undergoing revision and updating at this time as well.

1.0 OBJECTIVES OF NEW JERSEY'S ARTIFICIAL REEF PROGRAM

The construction of man-made fish habitat, commonly called artificial reefs, is recognized throughout the world as a means for enhancing fishery resources. Fishermen have long known the value of natural reefs, such as coral reefs and rock outcroppings, and shipwrecks as fish habitats and for centuries have created their own imitations to improve commercial and recreational catches. Scientific studies over the past several decades have confirmed what fishermen have learned by experience -- that many fish species inhabit areas where there is hard substrate or structure on the sea floor.

Benefits of artificial reefs, however, go beyond a good day's catch. Japanese studies (Vik [ed.], 1982) show that artificial reefs can also be used as fishery management tools for renewing natural resources that may be threatened with depletion. DEP is using knowledge and technology developed by reef programs around the world as the foundation upon which to build a progressive artificial reef program. By taking steps to increase or restore our dwindling marine resources, DEP intends to improve the marine fishery resources upon which a large number of New Jersey citizens depend -- for pleasure, profit or both.

With a responsible approach and a long-term commitment, DEP expects the program to achieve the following overall objectives:

1. create hard substrate, reef habitat for marine fish, crustaceans, shellfish and encrusting organisms;

2. provide spawning, nursery, refuge and feeding areas for marine life;

3. increase diversity and abundance of marine life ;

4. create fishing grounds for hook and line fishermen (anglers);

5. provide underwater structures for scuba divers;

6. provide economic benefits to recreational fishing industries

DEP's intent is to meet these objectives on a small portion (less than 1 percent) of New Jersey's sea floor in specific areas defined as artificial reefs. DEP is not attempting to change New Jersey's marine environment, but

rather, to enhance the limited reef site areas to benefit 150 species of fish and other marine life which prefer hard-substrate habitat. These species are indigenous to New Jersey waters, but restricted in numbers and extent due to the lack of available habitat.

These objectives will be achieved through the active involvement and guidance of DEP, which has established the following long-term plan for the development, maintenance, and monitoring of artificial reefs. This plan outlines the potential biological and socio-economic benefits of an artificial reef program in New Jersey, defines the planned network of artificial reefs, discusses the management responsibilities to which DEP is committed and establishes reasonable standards by which New Jersey artificial reefs will be built, monitored and maintained. Included in the plan are sections dealing with the following:

- reef site selection;
- construction materials;
- material preparation and construction procedures;
- configuration and design;
- risks and liability;
- monitoring and assessment;
- fisheries management;
- public information.

The standards, policies and procedures outlined in the plan will help ensure continuity and responsibility in the administration and coordination of the New Jersey Reef Program as well as in the physical management and maintenance of the State's artificial reefs. The establishment of New Jersey's Reef Program and this plan is in keeping with the National Fishing Enhancement Act of 1984 (P.L. 98-623) and the Sportfish Restoration Program administered by the U.S. Fish and Wildlife Service (Rassan 2000), which both recommend the creation of "responsible and effective" artificial reefs to achieve fishery enhancement objectives. The objectives of the Reef Program are consistent with DEP's Strategic Plan for Healthy Ecosystems, which mandates that "the health, diversity and integrity of New Jersey's

ecosystems will be returned, protected, enhanced and sustained" (Spinello 1998). The New Jersey Reef Program will use the general guidelines from the National Artificial Reef Plan (Stone, 1985a) and its revision, as appropriate, in developing New Jersey's artificial reefs.

1.1 Definitions of Natural and Artificial Reefs

According to the Random House Dictionary, a reef is a ridge of rock, sand or coral at or just below the surface of the water. This definition applies to reefs that are natural in origin. An artificial reef is a manmade imitation of a natural reef created by placing hard structures on the sea floor for the purposes of enhancing fish habitat and/or fisheries. In time, an artificial reef will attain the biological and ecological attributes of a natural reef.

Although many state programs have definitions in their respective state plans, the only generic definition is that of the Corps of Engineers with respect to Sec. 404 permitting requirements. This is, as contained in the Code of Federal Regulations (CFR), Title 33, Volume 3 (Revised as of July 1, 1999):

Sec. 322.2 – Definitions. (g) The term artificial reef means a structure which is constructed or placed in the navigable waters of the United States or in the waters overlying the outer continental shelf for the purpose of enhancing fishery resources and commercial and recreational fishing opportunities. The term does not include activities or structures such as wing deflectors, bank stabilization, grade stabilization structures, or low flow key ways, all of which may be useful to enhance fisheries resources.

1.2 Department Policy

This plan was developed in accordance with the goals of the New Jersey Coastal Zone Management Program. DEP policy regarding shipwrecks and artificial reefs, directly quoted from "Coastal Zone Management Rules, N.J.A.C. 7:7E" (DEP 2003), is as follows:

7:7E-3.13 Shipwreck and artificial reef habitats

(a) The shipwreck and artificial reef habitats special area includes all permanently submerged or abandoned remains of vessels, and other structures including but not limited to, artificial reefs, anchors, quarry rocks or lost cargo, which serve as a special marine habitat or are fragile historic and cultural resources. An artificial reef is a man-made imitation of a

natural reef created by placing hard structures on the sea floor for the purpose of enhancing fish habitat and fish stock. In time, an artificial reef will attain many of the biological and ecological attributes of a natural reef. Artificial reefs do not include shore protection structures, pipelines and other structures not constructed for the sole purpose of fish habitat.

1. Known sites include those shown either on National Ocean Survey (N.O.S.) Charts listed at N.J.A.C. 7:7E-3.7(a), the navigation channel rule, or listed in the following publications: W. Krotee and R. Krotee, Shipwrecks Off the New Jersey Coast (1966), B.L. Freeman and L.A. Walford, Angler's Guide to the United States Atlantic Coast Fish, Fishing Grounds, and Fishing Facilities (1974); and, B. Preim, J. Carlson, B. Figley, A Guide to Fishing and Diving New Jersey Reefs, (2000). In addition to known sites, unidentified remains of vessels may exist within tidal waters. Shipwrecks may also be considered historic or archaeological resources pursuant to N.J.A.C. 7:7E-3.36.

2. Shipwreck and artificial reef habitats may be subject to the marine fish and fisheries rule, N.J.A.C. 7:7E-8.2.

(b) Acceptable uses of shipwreck and artificial reef habitats include finfishing, shellfishing, and scuba diving.

(c) Any use, except archeological research, which would significantly adversely affect the usefulness of this special area as a fish habitat is prohibited. Persons conducting archeological research which significantly affects the usefulness of a shipwreck for fisheries purpose shall compensate for this loss by creation of an artificial reef of equal habitat value.

(d) Rationale: See note at the beginning of this subchapter.

7:7E-4.21 Artificial reefs

(a) Artificial Reefs are man-made structures intended to simulate the characteristics and functions of natural reefs created by placing hard structures on the sea-floor for the purpose of enhancing fish habitat and/or fisheries. In time, an artificial reef will attain many of the biological and ecological attributes of a natural reef. Artificial reefs do not include shore protection structures, pipelines, fish aggregating devices, and other structures not constructed for the sole purpose of fish habitat.

(b) New reefs shall be sited in accordance with the following:

1. The reef site shall not be located in the following special areas: surf clam areas (N.J.A.C. 7:7E 3.3), prime fishing areas (N.J.A.C. 7:7E-3.4), navigation channels (N.J.A.C. 7:7E-3.7), inlets (N.J.A.C. 7:7E-3.9), submerged infrastructure routes (N.J.A.C. 7:7E-3.12) and historic and archaeological resources (N.J.A.C. 7:7E-3.36);

2. The reef site shall be located in the Atlantic Ocean;

3. The reef site shall be located in a manner that minimizes impacts on commercial fishing operations;

4. The reef site shall not be located within shipping lanes, and/or anchorages;

5. The natural seafloor at the reef site shall have a firm substrate to minimize sinking of reef materials;

6. The reef site shall not be located within an area environmentally influenced by dredge disposal sites, sewage outfalls, or other areas known to experience hypoxic events, contaminated waters or sediment that may impair the quality of fish habitat; and

7. The reef site shall not be located in an area with currents that have the potential to cause material instability, scouring, or sanding over.

(c) Construction of new or expanded artificial reefs is conditionally acceptable provided that at the time of deployment, and at all times after creation, the following conditions are met:

1. The reef materials are of sufficient density so that it will not move outside of the approved reef boundary;

2. The reef materials shall not float;

3. The reef materials shall not pose a hazard to navigation;

4. The reef materials shall not pose a threat to the marine environment;

5. The reef materials shall not be toxic;

6. The reef materials shall not be hazardous;

7. The reef materials shall not be explosive;

8. The reef materials shall not be radioactive;

9. The following reef materials are acceptable for deployment, provided that (c)1 through 8 above are met:

i. Ships;

ii. Armored military vehicles;

iii. Manufactured reef habitats;

iv. Dredge rock;

v. Concrete and steel rubble;

vi. Demolition material free of floating debris;

vii. Obsolete submarine telephone cable; and

viii. Miscellaneous reef materials that meet the conditions in (c)1 through 8 above;

10. The reef material shall be deployed in the following manner:

i. No materials shall be deposited until notification has been provided to DEP at least 72 hours in advance;

ii. Inspection DEP prior to deployment, to ensure materials are not harmful to the marine environment, and will not pose a threat to human safety, and comply with the reef material conditions (c)1 through 8 above;

iii. DEP personnel shall directly observe and oversee the deployment of any reef materials;

iv. To the extent practicable, deployment of reef materials shall not

adversely impact the marine environment; and

v. The locations of artificial reef sites shall be recorded using a Global Positioning Satellite (GPS) system.

(d) An Artificial Reef Management Plan shall be submitted for each individual reef permit application and shall include the following:

1. A description of the proposed site;

2. A mechanism for recording materials used in constructing the reef; and

3. A monitoring schedule to measure the stability, durability and biological attributes of reef materials and impacts to the marine environment. The schedule shall include submission of monitoring reports, including a listing of materials deployed in the previous year, to DEP every year during reef construction, and every five years thereafter.

(e) It shall be the responsibility of the reef-builder to provide the location of the artificial reef to the US Department of Commerce, NOAA, National Ocean Survey, 1315 East-West Highway, Silver Spring, MD 20910-3282, for inclusion on nautical charts.

(f) Rationale: See the note at the beginning of this Chapter.

7:7E-3.13(d) Shipwrecks and artificial reefs

(d) Rationale: Shipwrecks and other natural or artificial materials can serve as critical habitat for benthic finfish and lobsters, and other invertebrates which prefer shelter in hard substrates otherwise uncommon in New Jersey's marine waters. These areas function as congregation, refuge, feeding and nursery areas for migratory species and support extensive fisheries. Although artificial reefs have been constructed for angling and diving, their goal is not solely to benefit human-use. A primary goal of an artificial reef is ecosystem and habitat enhancement. Due to the potential of reefs to serve as marine fish congregating areas, commercial and recreational fishing on artificial reefs may be regulated by DEP's Fish & Wildlife Division, the Atlantic States Marine Fisheries Commission and/or the Mid Atlantic Fisheries Management Council. As of 1999, New Jersey had 14

reef sites encompassing a total of 25 square miles of sea floor. The sites are located along the State's 120 mile coastline, with at least two reef sites within boat range from each of New Jersey's ocean inlets. Shipwrecks are also fragile historic and cultural resources. Scuba divers from New Jersey and other states visit artificial reefs extensively.

7:7E-4.21(d) Artificial reefs

Rationale: The construction of artificial reefs allows for both an increase in the marine resource biomass and the congregation of marine fish. Reefs in marine waters are public resources that are beneficial to the State's fishing industries, the sport diving community and to the marine ecosystem as a whole.

Proper siting of reef structures and use of appropriate construction materials is important to the success of the reef, while ensuring stability, safety and preventing degradation of the marine environment. In addition, proper siting of artificial reefs may reduce conflicts among competing users of ocean resources. For example, artificial reefs that are sited away from traditional commercial fish and shellfish areas may reduce conflicts between recreational and commercial fishers. Likewise, artificial reefs located outside of navigation areas and submerged infrastructure routes have a high potential to reduce ocean resource user conflicts.

Reef management plans will allow for uniform evaluation of reef structures during the permitting process and ensure the reef performs as designed.

Coordination of the Artificial Reef Program is the responsibility of DEP's Fish & Wildlife Division. Functions include review and approval of individual reef management plans, coordination and oversight of reef material preparation and placement, and coordination of Federal, State, regional, local and private activities associated with artificial reefs in New Jersey.

DEP may adopt management measures to address reef size limitations and cumulative impacts of reef structures, as needed.

1.3 Reef Plan Authority

While DEP has jurisdiction over the natural reefs, shipwrecks and

other hard-substrate habitats within the State's territorial sea (<3 NM) and while these habitats serve the same function as and are as environmentally important as intentionally-created artificial reefs, the Artificial Reef Management Plan for New Jersey concerns only those areas of the sea floor that have been permitted by the ACOE to DEP for the construction of artificial reefs. The policies presented in this plan are strictly limited to reefs within these permitted areas. Most of the sites permitted by ACOE lie offshore of the State's territorial sea.

1.4 Reef Program Goal

Outside the State's territorial sea, the living resources of the ocean belong equally to all of the nation's citizens. In meeting the objectives of the Reef Program, DEP's goal in both constructing and managing reefs is to spread the benefits of the reefs among as many people as possible. To accomplish this goal, DEP may have to restrict or discourage uses of reefs that foster an inequitable share of either the fisheries resource or access to the resource being taken or dominated by a small group of people.

2.0 FACTORS PROMPTING THE NEW JERSEY ARTIFICIAL REEF PROGRAM

The ocean off New Jersey, especially adjacent to the New York metropolitan area, is among the most intensively fished in the world (Freeman and Walford, 1974). In former times, the quantities of fish and shellfish occurring in our coastal waters exceeded the need placed upon them by people living along the shore. However, demand for seafood has increased and today, marine fisheries resources are being used at very high levels. The harvest of many species is above the level that can be biologically sustained.

Concurrent with the rise in fishing pressure, New Jersey's coastal zone has also undergone rapid population growth and development. In the past, wetlands were filled and estuaries polluted, resulting in extensive loss of fish and shellfish habitat, especially the productive shallow-water nursery grounds. Mining of ocean sand ridges for beach nourishment is a new problem which threatens to both destroy productive ocean ridges and bury inshore wrecks and groins.

Overfishing, pollution and habitat destruction have resulted in the decline of many of New Jersey's marine fisheries resources.

2.1 Loss or Lack of Hard Substrate Fish Habitat

The ocean floor off New Jersey is characterized by a sand or sand-mud plain interrupted by submarine sand ridges separated by mud or clay-bottomed depressions or sloughs (Steimle and Zetlin 2000). Although soft sea floor sediments support many species of fish and shellfish, such as winter and summer flounder, weakfish, surf clam and ocean quahog, such bottom topography offers limited habitat for fish and crustaceans that need the firm substrate or shelter of a reef. Species that are either associated with or dependent upon hard substrate habitat include the following: black sea bass, tautog, red hake, triggerfish, scup, cod, pollock, blue mussel and lobster. New Jersey has only one naturally occurring reef, the Shrewsbury Rocks, which is a horseshoe shaped rocky outcropping extending from the Shrewsbury River to East Rockaway Inlet on Long Island. Much of this reef remains covered by sand, with only scattered portions of rock protruding through the sea floor. Fishing grounds such as the Shrewsbury Rocks, 17 Fathom Bank, Cholera Bank, and the Southeast Ground are part of this reef (Figure 1).

Some 3,000 documented shipwrecks dating from colonial times through the most recent maritime disasters dot the New Jersey coast.

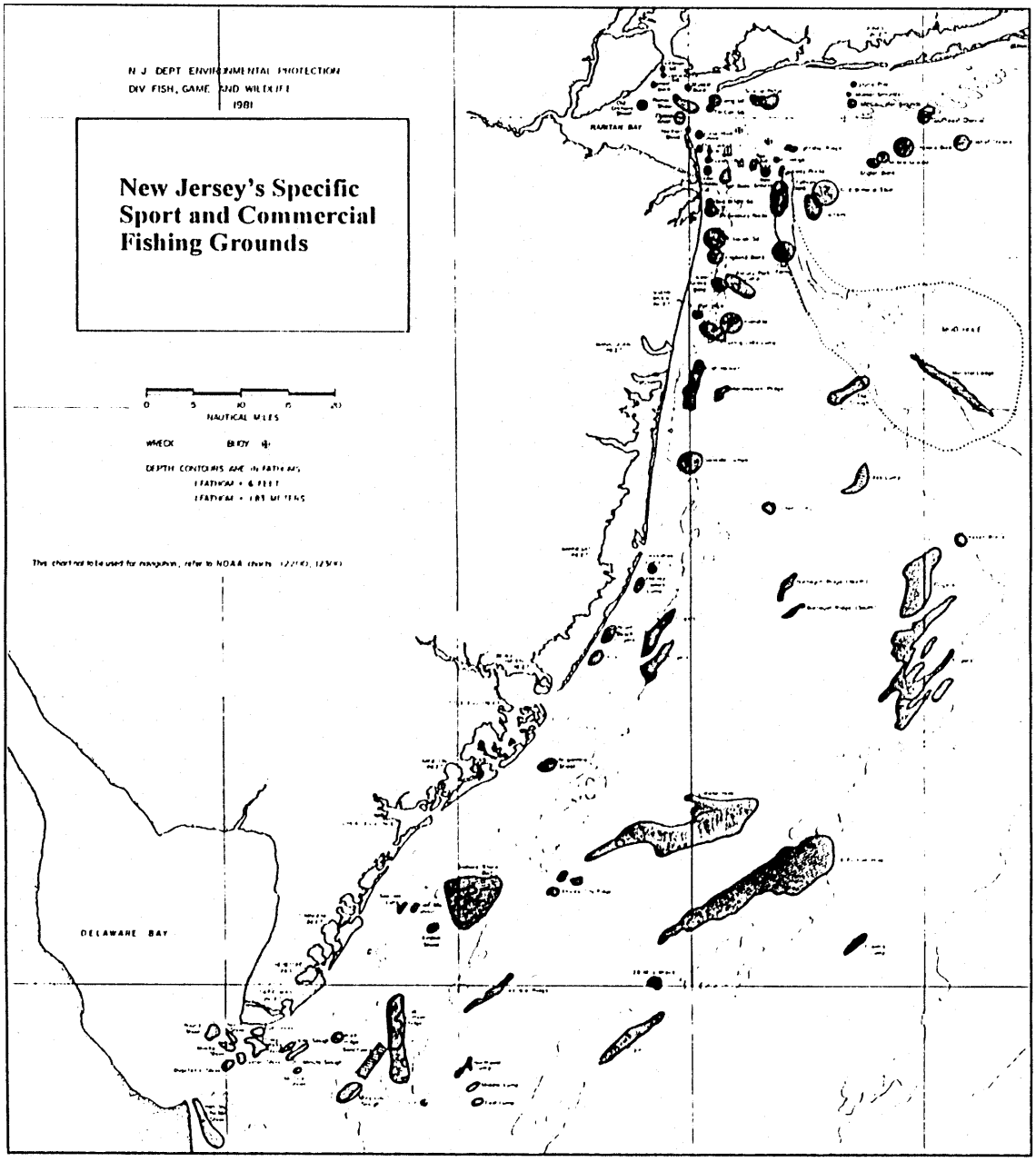


Figure 1. New Jersey's recreational and commercial fishing grounds.

Wrecks and bottom obstructions have provided fish habitat and supported a fishery in the past, but they are continually being damaged or destroyed by corrosion, abrasion, boring organisms, storm surges, fishing trawls and dredges, anchors, and salvage operations. The occurrence of new shipwrecks is not keeping pace with the deterioration of existing wrecks because of improved ship construction, navigation, rescue and salvage capabilities. Thus, a planned effort is needed to replace lost habitat with artificial reefs. Other hard, man-made structures that act as reefs include groins, jetties, seawalls, bridges and piers.

Steimle and Zetlin (2000) listed the following 11 man-made causes for reduction of reef habitat in the Middle Atlantic Bight:

(1) removal of reef structures deemed navigational hazards;

(2) siltation of reefs due to land run-off;

(3) damage to reefs from mobile fishing gear, such as trawl nets and dredges;

(4) burial of reefs by dredge spoil disposal;

(5) discharge of toxic chemicals;

(6) removal of docks and pilings in urban areas;

(7) non-point source pollution;

(8) loss of biogenic reef habitat, such as oyster bars;

(9) anorxia/hypoxia events;

(10) power plant intake and discharge killing larvae of reef-associated species; and

(11) sand mining and beach nourishment.

2.2 Increased Fishing Effort

Because of the uniform bottom conditions existing over most of the New Jersey sea floor, most fishing efforts take place in highly concentrated areas (Figure 1), resulting in excessive pressure on those areas by ever-increasing numbers of recreational and commercial fishermen.

2.2.1 Recreational Fishing Effort

According to Figley (1981), the popularity of marine sportfishing in New Jersey grew dramatically during the period 1950-1980. The rise in sportfishing has been attributed to the rapid development and increased population of New Jersey's coastline. The development of relatively inexpensive, dependable and low maintenance fiberglass boat hulls enabled more people to enter marine boating. The advent of dependable electronics gear -- radios, fathometers, radar and navigational devices -- not only added safety to small boats, but also enabled anglers to pinpoint areas where fish were concentrated.

In 1996, over 841,000 anglers fished in New Jersey's saltwater. These fishermen spent over $747 million on retail purchases and services to enjoy their sport that year, providing over 17,300 jobs in sportfish related industries (American Sportfishing Association, 1997). According to the Marine Recreational Fishing Statistics Survey (MRFSS), recreational anglers caught (kept and released) between 14 and 35 million fish annually in New Jersey during 1979 to 1999 (MRFSS, 1979-2000).

2.2.2 Commercial Fishing Effort

Economic factors that have contributed to our growing recreational fishery have also influenced the commercial fishery by increasing the demand for seafood. Although Americans were formerly not noted for high seafood consumption levels, there has been a continuous upswing in seafood popularity. Consumers now buy more frozen convenience or specialty seafood, eat more often in seafood restaurants, and are more willing to pay higher prices for these foods. Much of the pre-breaded fish sold in restaurants, fast-food franchises, and supermarkets consists of cod and hake, which are reef-associated species. Likewise, many popular fresh seafoods, such as lobster, black sea bass, and blue mussels also inhabit reefs.

In addition to a growing domestic market, a recent fishery has developed for live tautog, sea bass and other species to supply local and

overseas specialty markets. New Jersey's commercial marine fisheries landings more than doubled between the 1980s and 1990s.

In 1998, New Jersey's total commercial landings of all species was 197 million pounds. Despite the apparent growth in commercial landings, there are many serious problems facing these fisheries. Landings of edible seafood have remained relatively constant; the growth in harvest has largely been due to rising catches of industrial species, such as menhaden. Landings of higher value species, such as tuna, swordfish, tilefish and black sea bass, have been declining, while lower value species, including skate, dogfish and herring, have been rising (McCay, Grant and Adelajo, 1995). Many reef-associated species, including scup, black sea bass, tautog, cod, pollock and red hake, have been overfished and will require reductions in harvest through fishery management plans to bring their stocks back to sustainable levels.

3.0 EFFECTS OF ARTIFICIAL REEFS

3.1 Attributes of Artificial Reefs

Steimle and Zetlin (2000) listed the following biological habitat or fishery issues that can be addressed by reef habitat conservation, expansion or manipulation:

(1) artificial reefs can mediate the loss of structured habitat;

(2) increase bio-diversity by making sand environment more complex;

(3) provide refuge from excessive or damaging fishing by precluding the use of nets and dredges in an area;

(4) expand limiting habitat for reef-dependent and reef-associated species;

(5) nearshore reefs maintain access for land-based fisheries;

(6) improvement in water quality due to nutrient/bacteria/phyto-plankton removal by filter-feeding reef species;

(7) mitigation for unavoidable habitat loss; and

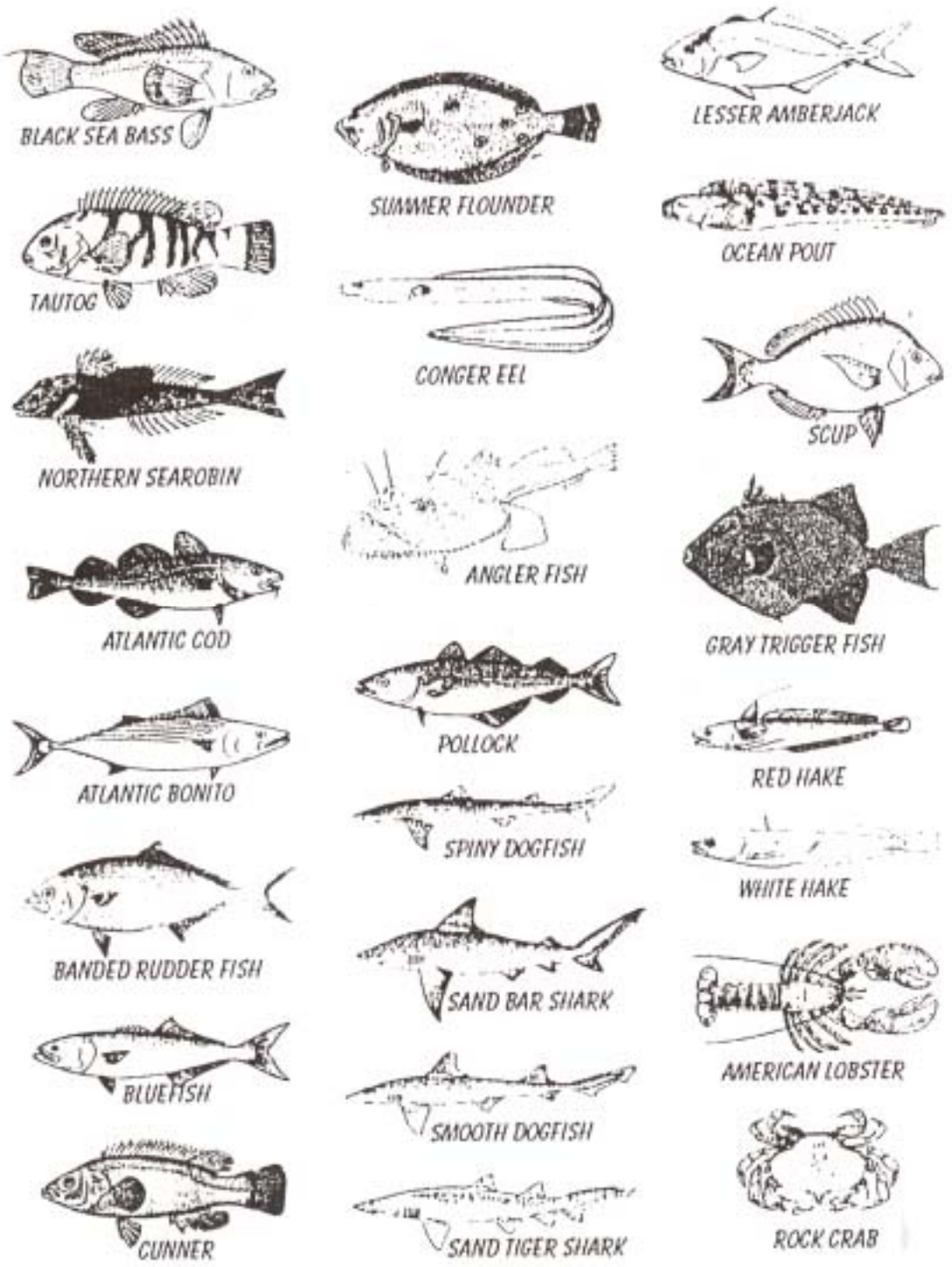
(8) opportunities for scientific research.

3.1.1 Biological Attributes

3.1.1.1. Reef Environment

Artificial reefs provide hard substrate habitat that supports a diverse marine life community composed of reef-associated and reef-dependent species (Figure 2). Reef habitats have certain physical characteristics that influence the species diversity and abundance of marine life inhabiting them. In contrast to the soft or unconsolidated sediments typical of the sea floor off New Jersey, reef habitats have solid, stable substrates, higher relief or profile, greater surface area per unit of sea floor footprint and numerous crevices and caverns. In simple terms, reef habitats are more diverse and complex than the sandy or muddy sea floor.

Figure 2. Species of New Jersey reef fish



The reef's firm substrate allows the development of a fouling or turf community on reef surfaces. This community consists of sessile epifauna, such as barnacles, mussels, hydroids, hard coral, tube worms, bryozoans, anemones and sponges, that attach to reef surfaces. Many fouling organisms are fast-growing, short-lived, highly productive animals that feed on plankton and detritus brought to them by ocean currents. Anchored to the firm reef substrate, fouling organisms can withstand the destructive force of ocean storms. The turf community is the most important living component of the reef environment. It harnesses the productivity of the water column, provides a food resource for fish and macroinvertebrates and affords cover for mobile invertebrates, such as crabs, shrimps, worms, snails, isopods and amphipods.

Because reef structures are three-dimensional, they offer more surface area for turf community growth per unit of sea floor footprint than do sand or mud habitats. Studies conducted by the Division have found densities of up to 13,000 mussels per square foot of reef surface (Steimle and Figley 1996) and 33,000 fouling organisms on reef structures covering one square foot of the sea floor.

In addition to increased surface area, the relief or profile of reef structures above the sea floor also exposes more reef organisms to currents, which carry both planktonic food to them and waste products and silt away. Thus, turf communities thrive on vertical surfaces as opposed to horizontal ones (Wendt, Knott and Van Dolah 1989).

The crevices and caverns of reef structures provide hiding places for juvenile and adult fish, lobster and crabs from larger ocean predators. Similarly, the turf community provides a carpet of cover for small mobile invertebrates, such as crabs, shrimps, snails, worms, isopods and amphipods. These small organisms are prime forage for many ocean fishes and require cover for survival. The Division is conducting an intensive survey of reef habitats to document colonization by marine life. Following five years of study, Division biologist found that one square meter of reef habitat was colonized by 432,000 marine animals of 145 species that had a collective biomass (weight) of over 58,000 grams (128 pounds) (Figley 2003). A square meter of reef habitat (about the size of a card table) provided a home for:

118,651	mussels
29,310	barnacles
16,626	worms
4,626	anemones
3,545	crabs
2,349	urchins
133	fish less than 4"
22	lobster

In addition, the experimental reef habitats were also colonized by colonial encrusting animals, like stone coral, bryozoans, hydroids and sponges, that could not be counted individually, but collectively accounted for hundreds of thousands of additional organisms.

The results demonstrate that reef habitat is biologically very productive. In particular, reefs provide needed refuge for juvenile fish and lobsters. Compared to studies regarding the marine life biomass of the sandy ocean floor, reef habitats foster 24 to 123 times more marine life than surf clam-dominated ocean sediments and 771 to 2,195 times more than polychaete (worm) crustacean-dominated ocean sediments of an equivalent area (Scott and Kelley 1998; Steimle 1990; Steimle 1985; Figure 4).

Similarly, Steimle et al. (2002) found that a concrete reef at the mouth of Delaware Bay exhibited an enhancement ratio of 168 to 354 times the biomass associated with surroundings and sediments. Seaman et al. (1992) provides an extensive summary of secondary productivity of artificial reefs from many studies.

3.1.1.2 Surrounding Environment

In addition to providing habitat for reef-associated and reef-dependent species, reef structures also provide benefits to marine animals that do not require structured substrates. Reef structures benefit pelagic fish in two ways. (1) They deflect cold, nutrient-rich bottom currents toward the surface, providing zoo plankton and baitfish with a food source (Lindquist and Pietrafesa 1989). Schools of baitfish often congregate over the top of high profile reef structures. (2) Large pelagic predators, like bluefish, tuna and sharks, visit reefs to feed on bait and reef fish and reef crustaceans.

Reef structures cover the sandy sea floor and therefore, reduce the amount of habitat available to open-bottom marine life.

How Reef Structures Benefit Marine Life

Surface Area – In the ocean, the surface area of a habitat is very important because it represents the interface between the surface upon which an animal lives and its exposure to the water column where it feeds and respires. The sandy sea floor is two-dimensional and has a relative surface area of 1. Three-dimensional reef structures, on the other hand, have height and thus more living area for the same relative unit of sea floor that they occupy. A human analogy would be a comparison between the floor space of a ranch house and that of a high-rise apartment building, both occupying the same footprint on the ground. The taller and more complicated a structure, the more surface area is available for marine life to colonize and consequently, the more productive it can be.

Firm, Stable Substrate – Unlike sand that is constantly shifting, reef structures provide firm, stable substrates for the attachment of marine life. Once anchored in place on a reef structure, marine life can withstand strong ocean currents and storms.

Habitat Diversity – Reef structures add a third component to New Jersey's marine environment, which now consists of sandy sea floor and water column habitats. The more diverse an environment, the more options are available to marine life and thus, the greater the diversity of species living there.

Refuge – The nooks and crevices of reef structures provide hiding places for juvenile and adult fish and other marine life to avoid predation.

Reduced Energy – The diffusion of currents by reef structures provides calm water, resting areas for fish, much like a boulder provides relief for a trout in a stream. Thus, the energy that would otherwise have been wasted upon swimming against the current can be better put towards growth.

Increased Biomass – The increased biomass (weight of marine life) associated with reef structures provides a ready source of food for fish and other marine life.

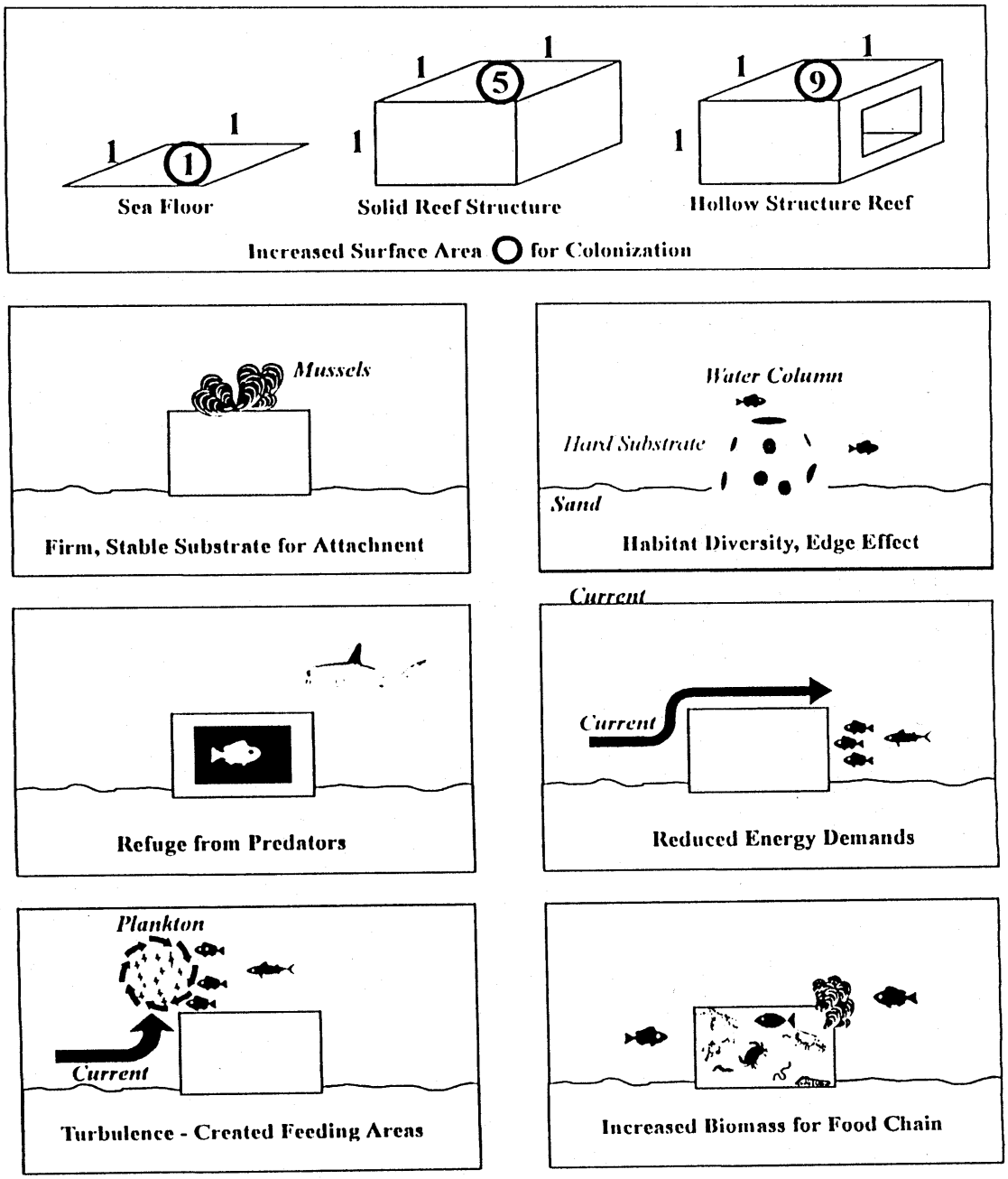
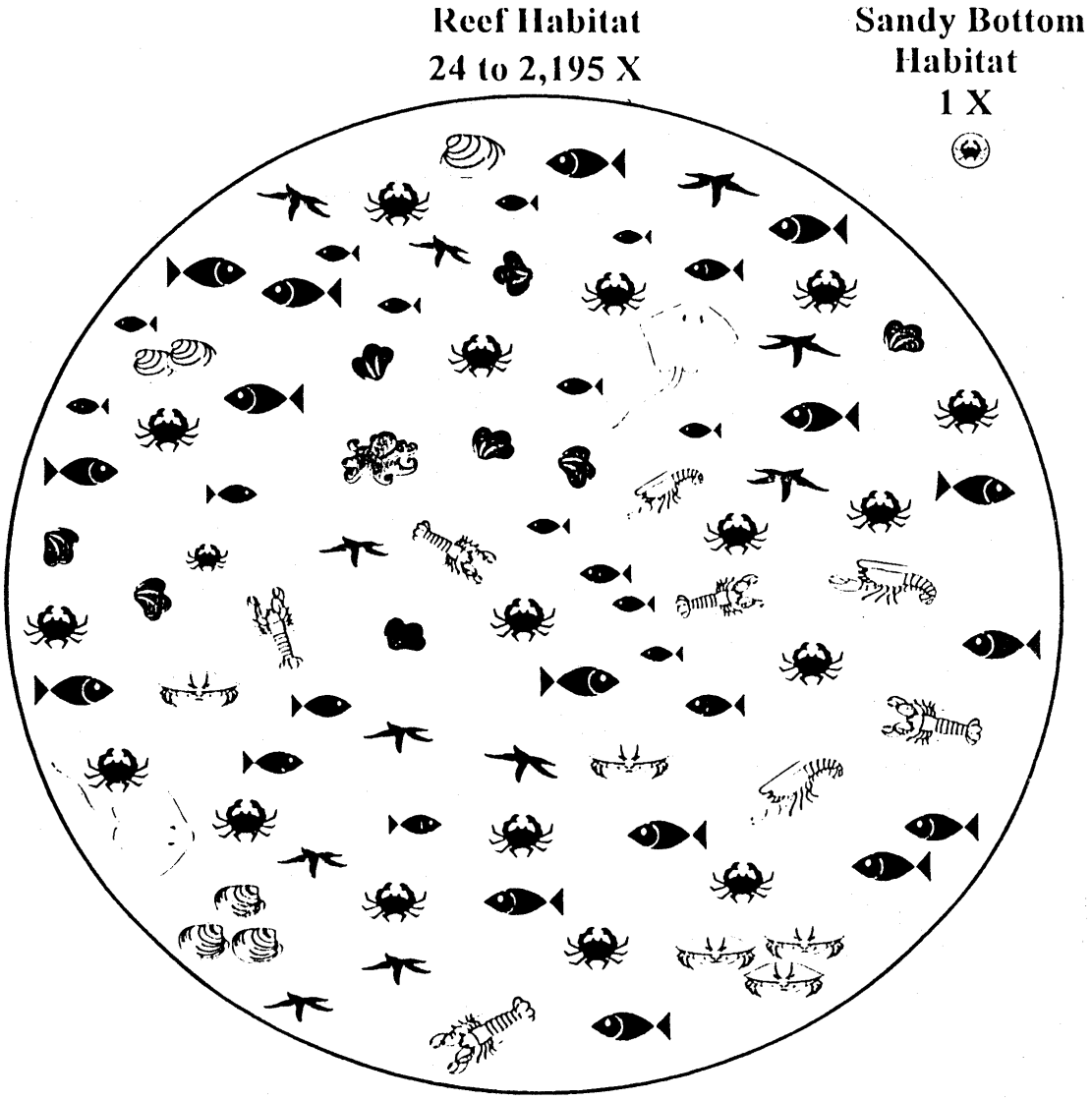


Figure 3. How reef structures benefit marine life

Figure 4. The relative biomass of reef and sandy bottom habitats



However, the area covered by reef structures off New Jersey is exceedingly small. After 19 years of reef-building effort, only 0.000045 percent of New Jersey's marine environment has been covered with reef structure (Figures 7 and 11); that means the sandy sea floor still accounts for 99.999955 percent of the state's marine environment. The intent of The Reef Program is not to change New Jersey's sea floor environment, but rather, it is intended to provide structured habitat within a very limited area (0.3 percent of the sea floor) to both replace and augment deteriorating shipwrecks for the benefit of indigenous species that are habitat limited.

Even though reef structures occupy a footprint of habitat, and thus displace sand-bottom species, their greatly enhanced biomass (discussed in section 3.1.1.1) benefits open-bottom marine life. Demersal fish species, like summer flounder, croaker, sea robin and anglerfish frequent reef sites to feed on reef-associated species. The waste products shed from reef communities enrich the surrounding sediments, promoting the growth of infauna, such as worms, bivalves, nematodes and crustaceans.

From an ecological perspective, reef structures add complexity and diversity to New Jersey's ocean environment, which is greatly dominated by sand bottom and open-water habitats. The interspersion of reef, sand and open-water habitats provides greater environmental complexity, which fosters greater bio-diversity than any of the three habitats affords by itself. Greater bio-diversity is an indicator of a healthier environment.

Reef sites may also serve as refuge areas for some open-bottom species. The inability to sweep reef sites with trawl nets and dredges may provide sanctuary for fish and clams. For example, unharvested, dense beds of surf clams, protected by reef structures, may act as breeding stock.

3.1.2 Socio-economic Attributes

3.1.2.1 Recreational Fisheries

Historically, wreck fishing in New Jersey was primarily an activity of party boats. Prior to 1950, charter boats mostly fished for pelagic species and there were very few private boats in use. In 1948, the 400 party boats based in New York and New Jersey directed their fishing effort as follows (Buller and Spear 1950):

Species	Percentage of Total Catch
Scup	24.1%
Sea Bass	31.5%
Mackerel	14.9%
Weakfish	6.4%
Summer Flounder	23.1%

The mean catch per angler-trip was 24 pounds and 15 pounds for the scup and sea bass fisheries, respectively.

In 1951, party boats accounted for 80.7 percent of the entire recreational saltwater catch in New Jersey. The species composition of party and charter boats was as follows (Hamer and Younger 1952):

Species	Party	Charter
Scup	49.1%	5.4%
Sea Bass	20.1%	7.5%
Red Hake	4.7%	-

In 1954, scup and sea bass were important species, comprising 19.8 percent of the total recreational catch in pounds (Younger and Hamer 1954). Harvest of wreck species was as follows:

Species	Pounds
Cunner	6,648
Tautog	37,535
Red Hake	309,891
Scup	1,996,935
Sea Bass	636,986

There were so few private boats at the time of the survey that their effort-catch was not even investigated. The growth in private boat ownership did not begin until the 1960s. Scup have declined in terms of population abundance, sportfish catch and in mean size from the 1950s to the present day. Today, scup are primarily small, young fish; larger, older age individuals are uncommon.

The first survey of wreck/artificial reef fishing in New York/New Jersey was conducted in 1970, when artificial reef development was minimal (Buchanan 1972). According to the survey, party boat anglers caught twice as many fish per hour, but only half as many species on man-made structures as on natural habitats, as follows:

Statistics	Natural Habitats	Artificial Reefs	Wrecks
Angler-Hours	87,026	2,751	10,516
Number Fish Caught	128,631	8,249	32,368
Fish/Angler Hour	1.5	3.0	3.1

Party boats spent only 2.7 percent of their bottom-fishing effort on artificial reefs in the New York Bight in 1970 (no reefs were available at the time to South Jersey anglers), as compared to 7.0 percent coastwide in 1988 (Figley 1989), to 19.9 percent in 1991 (Figley 1992), 27.8 percent in 1995 (Figley 1996) and 46.9 percent in 2000 (Figley 2001). The seventeen-fold increase between 1970 and 2000 is probably due to extensive reef-building efforts since 1984. Likewise, artificial reefs accounted for 6.7 percent of private boat bottom-fishing efforts in 1970 in the New York Bight as compared to 41.6 percent in 1991, 54.6 percent in 2000, and 89.7 percent in 2000. Private boat catch rates in 1970 were similar on reefs and natural habitats, as follows:

	Natural Habitats	Artificial Reefs	Wrecks
Angler-Hours	3,386	252	144
Number Fish Caught	4,916	357	333
Fish/Angler Hour	1.5	1.4	2.3

The advent of inexpensive LORAN (long-range aid to navigation) equipment in the 1970s led to a steady growth in wreck fishing by small, private boats. Growth in wreck fishing has also been augmented by a shift in effort away from other species that have recently declined in abundance. There is now considerable competition between both fishermen and divers and the various boat types for use of the limited number of shipwrecks and reef structures off New Jersey.

When DEP initiated its Artificial Reef Program in 1984, the only active site containing structures was the Sea Girt Reef. By 1988, an additional seven reef sites were established by F & W. Fishing pressure on the other seven sites was very low during the early years of the program, when both very little reef material was on the sites and very few fishermen were aware of the new reefs. After 1990, however, activity on reef sites increased dramatically. Between 1991 and 2001, the reef network expanded to 14 sites and the volume of reef structures increased from 192,000 cubic yards in 1991 to 2.6 million cubic yards in 2001 (Figley 1996), a 13-fold

increase. Now, the reef sites are used extensively, especially when other species are not abundant or out of season. Participation in fishing and diving on artificial reefs is expected to grow, especially among private boat owners, during the next few years.

Sportfish catches in New Jersey have been estimated by the MRFSS (NMFS 1984-2002) since 1979 (Table 1). Over the 24-year survey, annual catches have averaged 4.1 million sea bass, 961,000 tautog, 403,000 scup and 535,000 cunner. These data include catches of reef fishes by all fisheries. Recreational Wreck/reef fishing surveys were conducted by the Division during 1991, 1995 and 2000. Total catches of wreck/reef fishes on reef and non-reef areas throughout the state's ocean waters went from 7.2 million in 1991, to 3.8 million in 2000 and to 7.9 million in 2000 (Table 2). The recreational catch on the state's artificial reefs was 1.8 million fish in 1991, 1.2 million in 2000 and 4.8 million in 2000. During the 5-year period 1995–2000, the Marine Recreational Fishing Statistics Survey estimated that the total recreational catch of all saltwater species in New Jersey averaged 27 million fish annually. Thus, in 2000, the catch on artificial reefs accounted for 18 percent of all saltwater fish caught in New Jersey. Reefs contribute an inordinately large portion of the recreational catch given the fact that reefs only occupy 0.3 percent of New Jersey's ocean waters out to the edge of the continental shelf.

3.1.2.2 Scuba Diving

No historical data concerning New Jersey diving activity is available. In 1991, eight dive shops advertised a schedule of 494 wreck diving trips. Of those trips offering specified destinations, 9.8 percent were to wrecks on artificial reefs. Artificial reefs are most often used for check-out (certification) dives and for novices. Advanced divers reportedly prefer historical shipwrecks which have the potential of yielding collectible artifacts. However, with the sinking of the U.S.S. Algol on a deep water artificial reef, an increase in reef use by advanced divers occurred.

Surveys conducted during 1991 to 2000 by the Division show that artificial reefs are important for scuba divers in New Jersey (Figley 1992, Figley 1996 and Figley, 2001).

Percentage of Dive Trips to Artificial Reefs			
Boat Type	**1991**	**1995**	**2000**
Private	21.0	18.0	62.0
Charter	34.0	9.0	33.0
Party	20.0	9.0	No Data

Table 1. **Total recreational catch of wreck/reef species in New Jersey estimated by the National Marine Recreational Fishing Statistics Survey.**

	Number of Fish Caught			
Year	**Sea Bass**	**Tautog**	**Scup**	**Cunner**
1979	**689,000**	**344,000**	**311,000**	**322,000**
1980	**1,617,000**	**137,000**	**197,000**	**525,000**
1981	**441,000**	**117,000**	**30,000**	**252,000**
1982	**1,491,000**	**806,000**	**332,000**	**828,000**
1983	**4,978,999**	**440,000**	**30,000**	**2,149,000**
1984	**648,999**	**479,000**	**30,000**	**1,113,000**
1985	**3,781,000**	**1,074,000**	**192,000**	**165,000**
1986	**22,370,000**	**2,540,000**	**458,000**	**110,000**
1987	**1,412,000**	**1,771,000**	**257,000**	**894,000**
1988	**1,081,000**	**1,132,000**	**630,000**	**685,000**
1989	**2,773,000**	**990,000**	**668,000**	**479,000**
1990	**1,944,000**	**987,000**	**485,000**	**738,000**
1991	**2,487,000**	**1,067,000**	**781,000**	**161,000**
1992	**2,645,000**	**1,532,000**	**613,000**	**806,000**
1993	**4,732,000**	**1,086,000**	**224,000**	**577,000**
1994	**3,119,000**	**406,000**	**1,596,000**	**291,000**
1995	**6,411,000**	**1,663,000**	**791,000**	**706,000**
1996	**5,185,000**	**1,070,000**	**144,000**	**152,000**
1997	**6,164,000**	**616,000**	**162,000**	**424,000**
1998	**1,460,000**	**234,000**	**66,000**	**210,000**
1999	**2,177,000**	**837,000**	**352,000**	**204,000**
2000	**7,507,000**	**1,090,000**	**343,000**	**326,000**
2001	**6,289,000**	**1,474,000**	**630,000**	**689,000**
2002	**6,078,000**	**1,184,000**	**352,000**	**50,000**
24-yr. average	**4,062,000**	**961,000**	**403,000**	**535,000**

Table 2. Comparison of estimated recreational wreck/reef catches (kept and released) of 1991, 1995, and 2000 as determined by Division surveys.

Species	Numbers of Fish Caught (Kept and Released) 1991	1995	2000	Percent Change 2000/1991
Sea Bass	**4,923,135**	**2,164,355**	**5,663,350**	**+15**
Tautog	**550,158**	**383,160**	**417,634**	**-24**
Scup	**527,986**	**184,062**	**547,003**	**+4**
Red Hake	**176,033**	**352,975**	**86,999**	**-51**
Summer Flounder	**37,981**	**22,711**	**345,906**	**+811**
Triggerfish	**12,811**	**24,441**	**14,859**	**+16**
Cunner	**735,182**	**490,211**	**249,621**	**-66**
Total*	**7,232,833**	**3,808,909**	**7,867,779**	**+9**

***Includes unlisted species.**

Benefits Derived from Artificial Reefs

Marine Life Production and Biodiversity – Reefs add a hard-substrate habitat to NJ's sandy sea floor. Studies show that reef habitats are colonized by 200 species of fish and other marine life. Reef structures may have 800 to 1000 times more biomass (weight) of marine organisms than an equal area of sea floor.

Seafood – Both recreational and commercial fishermen harvest millions of pounds of fish, lobsters, crabs and mussels from NJ reef each year.

Fishing – Reefs are becoming extremely popular with recreational fishermen. Anglers caught 4.8 million fish on NJ reefs in 2000.

Diving – Artificial reefs accounted for about 36 percent of scuba diving activities in New Jersey's ocean waters in 2000.

Sportfish Industries – Without counting the costs of boats, recreational fishermen and divers spent about $15 million in 2000 to enjoy fishing and diving on NJ reefs.

Improved Water Quality – Many of the animals, such as blue mussels, barnacles and sponges, which live in large numbers on reef structures—filter algae, organic matter and bacteria from the water column, thus improving both the cleanliness and clarity of NJ's ocean waters.

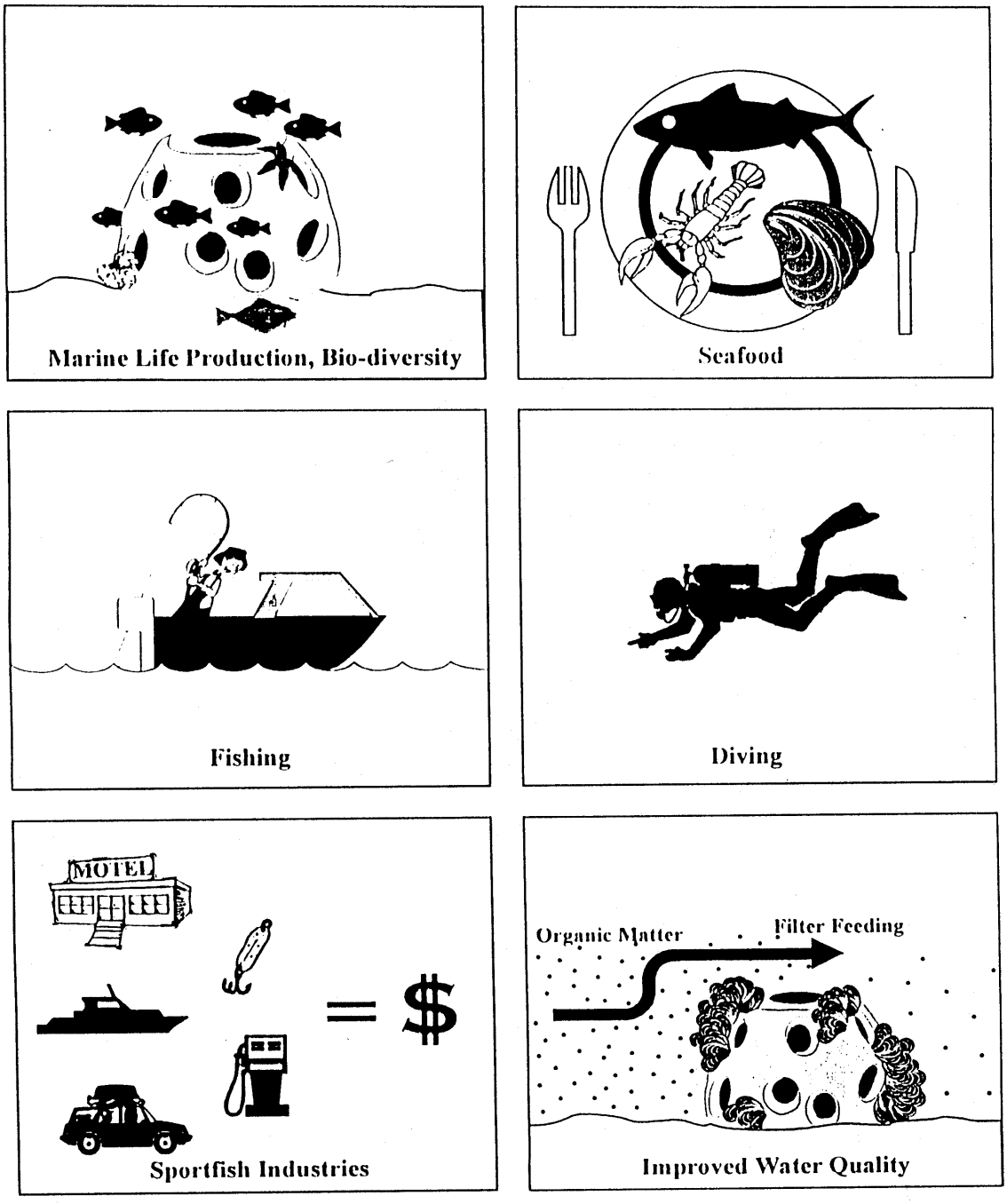


Figure 5. Benefits derived from artificial reefs.

While divers harvest far less seafood than recreational fishermen, wrecks and reefs offer opportunities to spear fish, catch lobster and pick mussels. The estimated harvest by divers for 1991 to 2000 is as follows:

Harvest of Recreational Scuba Divers				
Seafood	Units	1991	1995	2000
Fish	Numbers	6,000	4,000	9,000
Lobster	Numbers	21,000	23,000	17,000
Mussel	Pounds	50,000	23,000	32,000
Scallop	Numbers	32,000	15,000	1,000

3.1.2.3 Commercial Fisheries

Commercial fishing on reefs is primarily limited to traps (pots), because reef structures snag other types of gear, making it impractical to use nets or dredges on reef sites. During 1998 - 2001, harvests of commercial trap fisheries in New Jersey averaged 1.1 million pounds of fish and shellfish annually, with an average dockside value of $3.4 million dollars (Table 3).

Surveys conducted F & W indicated that commercial pot-fishing effort amounted to over 16 million and 10 million pot-days (pot-day = 1 trap set for 1 day) of fishing during April to December of 1991 and 1995, respectively (Figley 1992 and Figley 1996). Effort directed at artificial reefs amounted to 482,000 and 365,000 pot-days, representing 2.9 and 3.6 percent of total commercial pot fishing effort during 1991 and 1995, respectively (Table 4).

3.2 Risks of Artificial Reefs

Although after 19 years of reef building experience, DEP is optimistic about the effectiveness of the Reef Program in meeting its objectives, it is well aware of past artificial reef failures in areas worldwide. Bohnsack and Sutherland (1985) reviewed numerous documented artificial reef failures, some attributed to natural causes, such as storms and corrosion, and others to human error, such as using unstable reef materials and selecting inappropriate reef sites. These authors also cited biological and socio-economical failures whereby artificial reefs did not result in increased fish abundance and greater angler success. The Reef Committees of the Atlantic

Table 3. Commercial landings and dockside value of New Jersey's pot fishery for 1998- 2001.

Species	Landings (pounds)/Value			
	1998	1999	2000	2001
Sea Bass	258,000 $382,000	282,000 $440,000	229,000 $300,000	128,000 $166,000
Tautog	22,000 $29,000	14,000 $25,000	16,000 $30,000	20,000 $35,000
Red Hake	3,000 $1,000	2,000 $1,000	2,000 $1,000	2,000 $1,000
Ocean Pout	1,000 $1,000	2,000 $1,000	1,000 $1,000	1,000 $1,000
American Lobster	706,000 $2,569,000	911,000 $3,550,000	846,000 $3,510,000	550,000 $2,350,000
Rock Crab	43,000 $38,000	63,000 $52,000	25,000 $22,000	9,000 $10,000
Jonah Crab	74,000 $45,000	12,000 $12,000	15,000 $13,000	17,000 $19,000
TOTAL	1,107,000 $3,065,000	1,286,000 $4,081,000	1,134,000 $3,877,000	727,000 $2,582,000

Table 4. Fishing effort of New Jersey commercial pot fishery during April to December, 1991 and 1995.

Statistic	1991	1995
Total Pot-days of Effort	**16,066,620**	**10,143,333**
Pot-day on Artificial Reefs	**481,998**	**365,160**
Percentage of Effort on Reefs	**2.9**	**3.6**

and Gulf States Marine Fisheries Commissions (ASMFC and GSMFC) have examined the successes and failures of reef programs from Massachusetts to Texas and have prepared guidelines concerning the appropriateness and preparation of a wide variety of reef-building materials (Lukens 1997)

After 19 years of experience building over 2,000 patch reefs, DEP's F & W has identified many potential risks associated with artificial reefs and has predicated most of the procedures, policies, guidelines and restrictions in this artificial reef plan on the foreseeable risks discussed below.

3.2.1 Biological Risks

Artificial reef technology is a relatively new science with somewhat limited knowledge of the biological risks. Possible biological risks associated with artificial reefs include, but are not limited to:

- leaching of chemical pollutants from reef materials;
- mortality of marine life due to an oil spill resulting from a vessel sinking;
- displacement of species that do not inhabit reefs by reef structures;
- over-enhancement of some species populations to the detriment of natural competitors or prey;
- over-harvest of reef species;
- introduction of non-endemic marine life species;
- disruption of migratory patterns (similar to the “short-stopping” of geese);
- concentration of marine life populations, which could increase the spread of diseases or lead to fishkills during anaerobic events (oxygen depletion); and
- mortality of fish when using explosives to scuttle ships.

Further biological assessments (Sections 5.8 and 6.5.4.) of artificial reefs (and the species they influence) may reveal additional biological risks and provide the means to formulate more knowledgeable

management decisions and strategies regarding artificial reefs.

3.2.2 Socio-economic Risks

Possible socio-economic risks associated with artificial reefs include, but are not limited to:

- user conflicts, such as those between anglers and divers or recreational and commercial fishermen, or between fisheries and other competing uses of the ocean, such as navigation, sand mining, undersea cables and pipelines;
- increased demands on the existing coastal access facilities;
- contamination of seafood by chemicals leached from reef structures;
- injury or death to a scuba diver caused by reef structure;
- lack of public interest in using reefs; and
- excessive materials and construction costs that may not bring the expected return on investments.

In anticipation of known or perceived socio-economic risks, DEP has developed strategies for offsetting potential problems. For example, the guidelines for site selection (Section 6.1), reef configurations and jurisdictional powers (Section 5.5) should help minimize user conflicts. The proposed artificial reef network (Section 4.0) should allow an equitable distribution of reefs along the New Jersey coast, thus, helping to prevent heavy strains on any single coastal access area. Information distribution (Section 5.7) should stimulate public interest in, and use of, artificial reefs. The careful selection and preparation of reef materials (Section 6.4) will reduce or eliminate potential chemical contamination problems. Other monitoring and pilot programs (Section 6.5) will provide the means for determining if the social and economic objectives of the artificial reef program are being achieved and may also expose unanticipated risks. New or modified monitoring efforts will be added as needed to assess additional risks.

3.2.3 Physical Risks

Artificial reefs are considered fishery management tools

because they are capable of manipulating fish habitat. Using any tool that alters the environment involves physical risks that are primarily related to the construction, placement, durability and stability of artificial reefs. These risks include, but are not limited to:

- accidental sinking of artificial reef material off the designated reef site, which could result in damage to fishing gear or an impediment to navigation;
- movement of material by currents or wave forces from designated reef sites into areas where it may conflict with other maritime or coastal interests, such as swimming beaches;
- dragging of materials off reef sites by anchor lines, commercial trawls or dredges;
- disintegration of reef material causing the habitat to not function as intended;
- siltation or shoaling over of reef materials;
- violation of clearance requirement, thus presenting a threat to navigation; and
- the permanence of the physical alteration brought about by reef construction and the difficulty of removing reef structures.

Over the past 19 years, DEP has gained considerable experience from its reef building efforts and those of other Atlantic and Gulf Coast states. DEP has adapted additional quality control measures into its procedures and policies since the initial plan in 1987 and therefore, expects to minimize physical risks. For example, quality standards have been set for materials (Section 6.2), procedures have been developed for both preparing these materials and supervising deployment (Section 6.4), and monitoring procedures have been implemented to verify the stability of reef materials on the sea floor (Section 6.5). DEP acknowledges that additional monitoring studies may be needed to help determine if other preventative measures are warranted.

3.3 Liability

According to the National Fishing Enhancement Act of 1984 (Section 205c:p3), "The Secretary (of the Army) may not issue a permit subject to this section unless that person demonstrates to the Secretary the financial ability to assume liability for all damages that may arise with respect to an artificial reef and for which such permittee may be liable." Furthermore, a person to whom a permit is issued in accordance with subsection (a) [compliance with Federal laws] and any insurer of that person shall not be liable for damages caused by activities required to be undertaken under any terms and conditions of the permit, if the permittee is in compliance with such terms and conditions.

A risk survey conducted by DEP in 1993 identified the following potential environmental and socio-economic risks associated with the reef program:

- Movement of reef structures into commercial fishing grounds or onto the beach;
- diver injury on reef;
- sinking material outside reef boundaries;
- injury to civilian during reef construction;
- user conflicts on reefs;
- release of pollutants (oil, toxic chemicals, etc.) from reef materials; and
- release of floatables (wood, plastic, etc.) during reef deployment.

The State of New Jersey will utilize the following policy to minimize risk and comply with liability conditions of the National Fishing Enhancement Act of 1984:

- F & W personnel will monitor and inspect all reef construction activities to insure compliance with all permits issued to the State. These personnel will also work with Federal representatives to insure compliance with appropriate Federal codes.
- vessels and materials donated to the Reef Program will be the responsibility of the donor until the vessel or material is sunk or placed

on the designated reef at a site designated by the State in accordance with State and Federal specifications. In certain cases, such as the procurement of an obsolete military vessel or reef structures fabricated with F & W funding, F & W will assume both ownership and responsibility for the materials prior to their deployment;

- marine contractors performing work for the Reef Program will assume full responsibility and liability for vessels or materials from the time the materials are turned over to their custody by the donor until the materials are placed on the designated site, in accordance with State and Federal specifications and in the presence of an authorized State representative. The marine contractor will also be required to assume responsibility for the safety and actions of its personnel and equipment and have insurance appropriate for the work to be performed for the State;

- artificial reef users will be advised through public announcements that they may use a State artificial reef at their own risk;

- no portion of this document is intended to imply that the State shall, or intends to, waive Sovereign Immunity as specified in the New Jersey Constitution; and

- should appropriate insurance coverage become available for artificial reefs, the State will consider participation in such a program.

4.0 NEW JERSEY ARTIFICIAL REEFS

4.1 History of the State's Reef Program

DEP's Reef Program began in 1984 with the sinking of the steel schooner Dykes on the Sea Girt Reef. At that time, there were three ocean reefs off New Jersey, each permitted by a private organization as follows:

Reef Site	Permittee
Sea Girt Reef	Artificial Reef Committee, NMFS
Garden State South	Garden State Reef Committee, Inc.
Ocean City	Ocean City Artificial Reef, Inc.

One of the first steps in the program was to consolidate all of the reef permits under the auspices of DEP by transferring ACOE permits from the private permittees to the State. Over the next few years, DEP applied for and received permits for 11 other reef sites to establish a statewide reef network encompassing 14 reef sites.

Reef construction efforts started very slowly, but as news of the program spread among the marine industries that provide reef material, reef building increased dramatically (Table 5). Between 1984 and 2002, DEP's Reef Program built 2,098 patch reefs on its network of 14 reef sites.

4.2 Reef Network

In the original Reef Plan, a network of 15 inshore and offshore artificial reefs was planned to ensure anglers and divers from each inlet along the New Jersey coast reasonable and equitable access to an artificial reef (Figure 6). The reasons for having both inshore and offshore reefs are to provide habitat for a wider range of species (cod and pollock, for example, would prefer deeper, offshore reefs) and to permit the use of a variety of artificial reef materials with different profiles. Inshore reefs – those located 2-10 miles from shore in 45- to 85- foot depths – will be built with low-profile materials, such as rock, concrete and steel rubble, and fabricated reef units, as well as small vessels and barges.

Although some of the low profile materials will also be used on offshore reefs (those located 10-30 miles from shore in 80- to 140- foot depths), offshore sites will include large vessels with high profiles, such as liberty ships, freighters and tankers.

Table 5. Number of patch reefs deployed by year.

	Number of Patch Reefs							
Year	**Concrete**	**Rock**	**Tire Units**	**Vessels**	**Tanks**	**Reef Balls**	**Other**	**Total**
1984	-	-	1	1	-	-	-	2
1985	1	-	2	5	-	-	-	8
1986	-	-	6	8	-	-	-	14
1987	8	-	8	6	-	-	-	22
1988	19	-	29	6	-	-	-	54
1989	8	-	32	13	-	-	-	53
1990	7	7	24	6	-	-	1	45
1991	22	58	33	5	-	-	1	119
1992	52	148	24	3	-	-	-	227
1993	3	148	15	7	-	-	-	173
1994	11	29	19	9	6	-	3	77
1995	34	-	9	5	58	-	1	107
1996	2	-	22	5	77	-	1	107
1997	1	2	5	10	84	-	-	102
1998	5	-	5	4	116	-	-	130
1999	5	-	-	2	56	15	-	78
2000	-	-	-	4	-	34	20	58
2001	17	427	-	5	-	2	-	451
2002	19	192	-	5	-	40	15	271
TOTAL	214	1,011	228	109	397	91	48	2,098

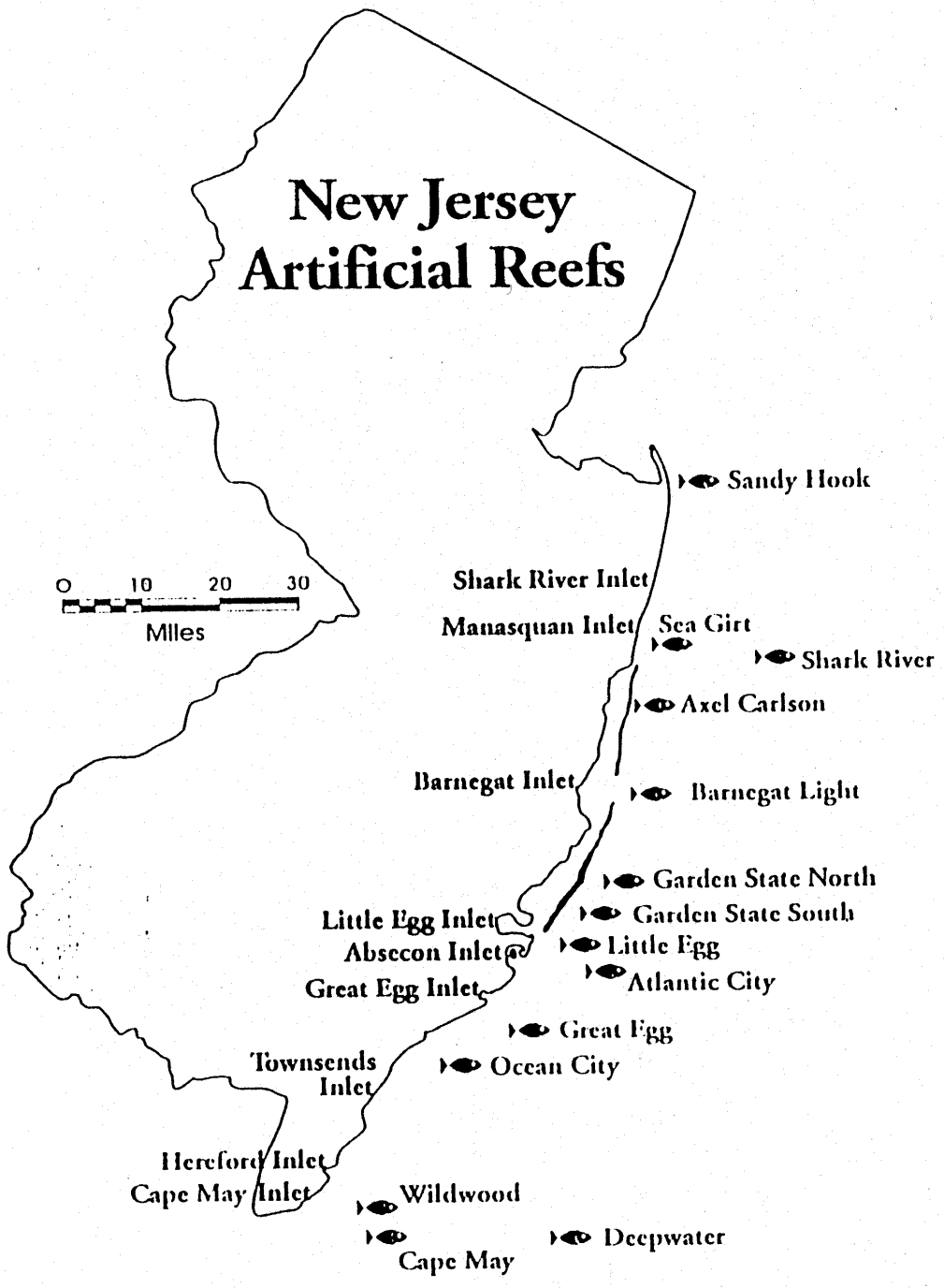


Figure 6. New Jersey's artificial reef network

4.2.1 Existing Reef Sites

As of 2003, there were 14 reef sites permitted by the ACOE along the New Jersey coast. DEP holds all of these permits. Of these permitted sites, 11 sites are inshore (<10 miles), two are offshore (>10 miles) and one has both inshore and offshore portions. (Table 6, Figure 3). Of the inshore sites, two also require Department permits because they are located within State waters (<3 miles).

These reef sites occupy 24.6 square miles of sea floor, representing approximately 0.7 percent of the 3,750 square miles of sea floor out to 30 miles and 0.3 percent of the 8,750 square miles of sea floor out to 70 miles (edge of continental shelf) off of New Jersey (Figure 7).

A potential modification for eight of the State's fourteen reef sites would be to square the corners and align the boundaries of sites along latitude-longitude lines. This would result in a significant increase in the area of several reef sites. Sites that could be modified include: Sea Girt, Axel Carlson, Garden State North, Garden State South, Atlantic City, Ocean City, Wildwood and Cape May.

The current ocean reef network has the following two gaps:

- An inshore, 60-foot deep reef off Townsends Inlet
- An offshore, deepwater site (150 to 180 feet deep) to accommodate large, Navy vessels.

4.2.2. Potential Reef Types

The following options for expanding New Jersey's reef network by permitting additional reef types and sites may be considered in the future:

- refuge, no-fishing, reefs;
- research reefs;
- commercial fishing reefs;
- estuarine reefs;
- interstate reefs

Table 6. Statistics of New Jersey's 14 reef sites in 1999.

Reef Site	Area (sq. miles)	Distance Offshore	Clearance (ft)	Depth Range (ft)	Number of Patch Reefs
Sandy Hook	**1.4**	**1.4**	**40**	**40-60**	**524**
Shark River	**0.7**	**14.0**	**50**	**119-128**	**18**
Sea Girt	**1.3**	**3.5**	**50**	**60-75**	**86**
Axel Carlson	**4.0**	**2.1**	**50**	**66-82**	**53**
Barnegat Light	**0.9**	**3.0**	**50**	**46-58**	**117**
Garden State North	**1.1**	**6.5**	**52**	**66-83**	**101**
Garden State South	**0.6**	**5.1**	**52**	**57-63**	**62**
Little Egg	**1.5**	**3.8**	**50**	**48-60**	**41**
Atlantic City	**4.0**	**8.5**	**50**	**55-94**	**51**
Great Egg	**1.0**	**7.0**	**50**	**47-70**	**45**
Ocean City	**0.8**	**4.5**	**50**	**56-66**	**56**
Deepwater	**0.7**	**25.1**	**50**	**115-125**	**3**
Wildwood	**2.1**	**4.5**	**30**	**40-63**	**41**
Cape May	**4.5**	**8.5**	**30**	**50-73**	**126**

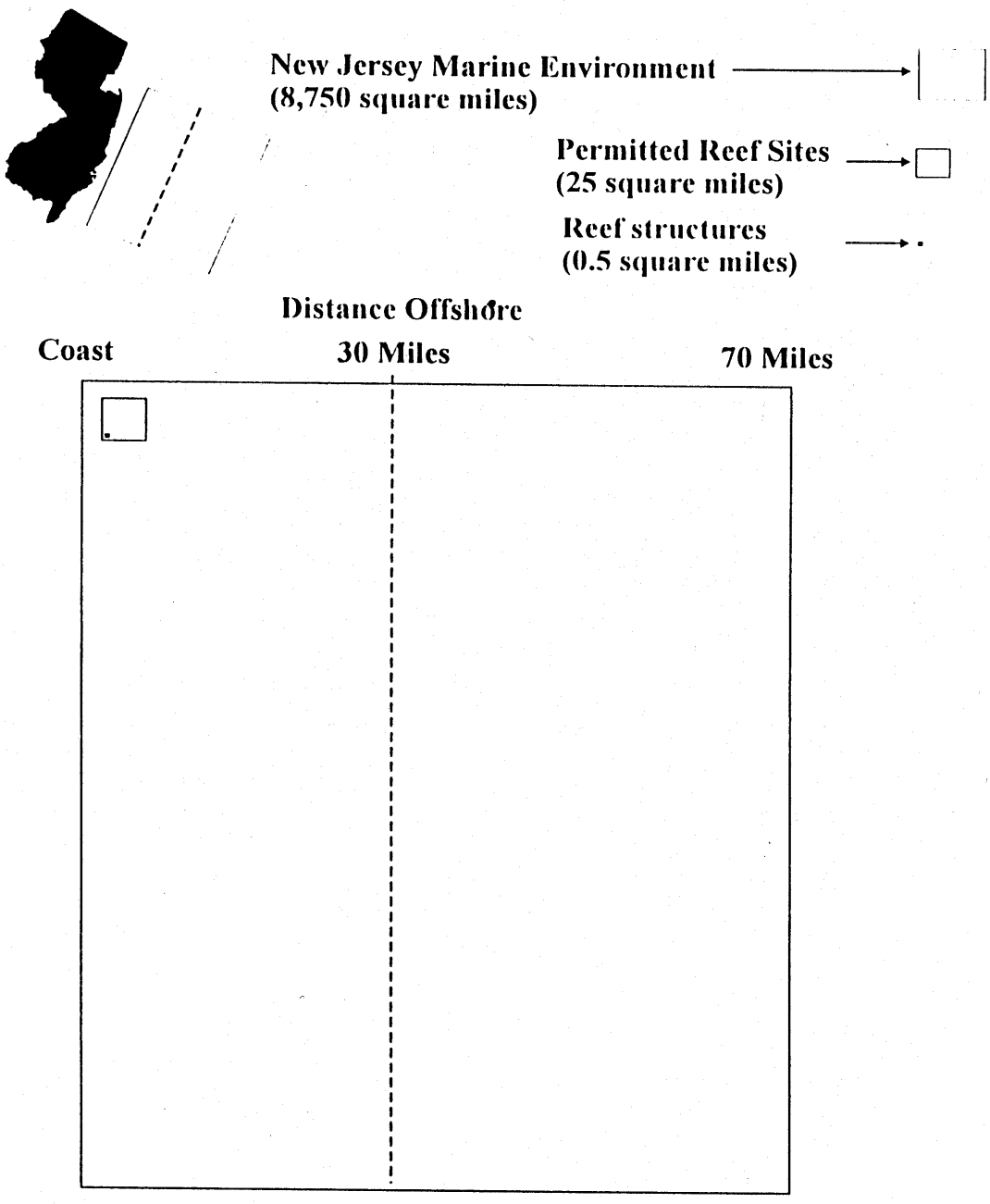


Figure 7. A representation of the relative areas of sea floor of New Jersey's permitted reef sites, reef structures and marine environment out to the edge of the continental shelf in 2001.

Future inshore and offshore artificial reef sites should range in size from 0.5 - 5 square miles, although offshore commercial fishing reefs might be much larger. The number and size of reefs in the network may need to be adjusted as our knowledge of artificial reefs improves.

4.2.2.1 No-Harvest Reefs

No-harvest reefs would be established for the purpose of providing a sanctuary for marine life, with no harvest of any kind permitted. No-harvest reefs would produce fish and shellfish to augment coastwide populations. These protected populations would also add recruits to the fishery when individuals move or migrate away from the sanctuary into areas open for harvest. The concept of no-harvest reefs, called Marine Protected Areas (MPA) or marine sanctuaries, is gaining popularity, especially in the South Atlantic, although it is also being viewed with skepticism by many fishermen who object to closing local fishing grounds. The primary concern of fishery managers is the difficulty of enforcement of refuge of no-harvest reefs.

4.2.2.2 Research Reef

Research reefs would also be no-harvest sites created so that reef communities could be studied in an unexploited state, without the dramatic influence of man's harvest. Research reef sites would probably be small in size and close to shore.

4.2.2.3 Commercial Fishing Reefs

Commercial fishing reefs could be established for lobster and fish pot fisheries. These sites would probably be located more that 25 miles offshore to reduce conflicts with recreational fishermen. Such sites could be as large as 10 square miles. However, at this time, there is no funding available to construct commercial fishing reefs.

4.2.2.4 Estuarine Reefs

DEP will evaluate the feasibility of developing estuarine reefs in New Jersey estuaries, bays and sounds. Such decisions will be largely based on the effectiveness of estuarine reefs now being built in Delaware and Chesapeake bays. Estuarine reefs could either be placed in easily accessible locations for use by fishermen and divers or they could be employed as

estuarine sanctuaries in areas where harvesting would be prohibited, thus allowing populations of reef species to increase without exploitation. In addition, DEP should assess and develop a policy regarding the use of estuarine reefs to mitigate habitat stressed by or lost to development, dredging, pollution or other environmental damage.

Estuarine reefs would be developed under the same general guidelines covering ocean reef development. Factors for selecting an estuarine site will include accessibility, water quality, availability, depth, bottom type, current, tidal range, salinity, and conflicting use.

Reefs built in estuaries would offer a unique management opportunity because they would be in territorial waters under State jurisdiction. This would allow DEP more comprehensive management control over harvesting methods, harvest seasons, quantity and size of catches, the types of species that may be harvested and whether or not harvest should occur at all on the reef.

4.2.2.5 Interstate Reefs

The development of interstate reefs that would be located in ocean areas that border adjoining states is a potential way to not only reduce the area of sea floor needed as reef sites, but also reduce competition between reef programs for reef material. At present, the USACOE is proposing a harbor deepening project that will generate ten to twenty million cubic yards of rock. A joint reef site between New York and New Jersey could provide a site near New York Harbor for placement of rock.

In addition, the Navy is considering the possibility of sinking very large ships on reefs as a means of reducing the size of the inactive fleet. These large ships may require depths of 150' to 200', which exceed the depth ranges of current reef sites off New York, New Jersey and Delaware. Deepwater sites off New York-New Jersey and Delaware-New Jersey would provide the necessary depths and enable New Jersey to receive large naval ships.

Why New Jersey's Marine Environment Suits Reef Development

Shallow Coastal Plain – New Jersey has a very wide, gently sloping, shallow coastal ocean floor. The edge of the continental shelf is located 70 to 80 miles offshore of the coast. The shallow coastal plain absorbs the energy of long-period ocean waves that are driven towards shore by offshore, deep-sea storms. The reduction in storm energy helps prevent movement and destruction of reef structures.

Lack of Hard-Substrate Habitat – Over 99 percent of New Jersey's sea floor consists of sand, gravel and mud. There are only a few rock outcroppings on the sea floor; other hard-substrate habitat is limited to 3,000 shipwrecks and other manmade debris. The purpose of building reefs is to augment the small amount of hard-substrate habitat that now exists. Hard-substrate benefits about a dozen species of fish and a hundred species of invertebrates.

Sand Supports – Unlike soft mud which allows heavy objects to sink, possibly even deep enough to disappear, hard sand and gravel provides support for reef structures. However the unconsolidated granular nature of sand and gravel also present problems. The flow of water from currents around a reef structure causes scoring and allows the structure to settle where sand grains have been flushed away. Furthermore, large, storm waves can "liquefy" the sea floor by suspending sand grains in the water. When this happens, reef structures subside until they reach firm, unmoving sand.

Highly Productive – The temperate ocean waters off New Jersey are rich in nutrients, which support luxuriant growths of phytoplankton. These microscopic algae represent a large amount of energy available for the reef food web and consequently, can support a rich and abundant marine life community on reef structures.

Intensive Fisheries – The New York Bight is one of the most intensively fished areas by recreational and commercial fishermen in the U.S. This not only means that large amount of seafood are needed to satisfy the demand, but also that there is intense competition among fishermen to use fishing sites. Competition is particularly severe when fishing sites are limited in number and size, such as shipwrecks and reefs.

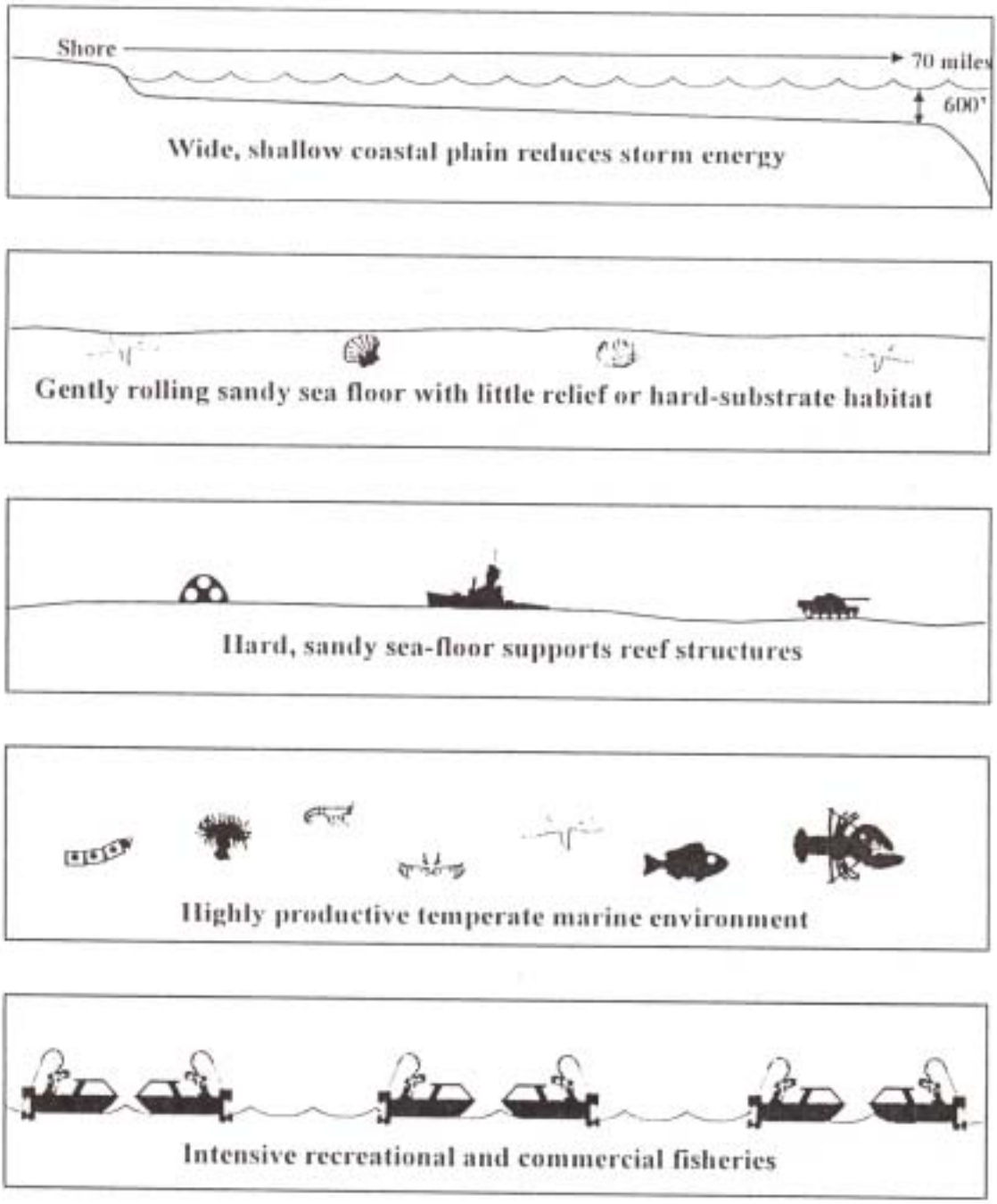


Figure 8. Why New Jersey's marine environment suits reef development.

5.0 ARTIFICIAL REEF PROGRAM COORDINATION AND ADMINISTRATION

As outlined in the National Artificial Reef Plan, states have the authority to manage aquatic resources and submerged lands within the territorial sea, and are thereby responsible for approval of all artificial reef construction in state waters. To this extent, DEP's role will be to retain and strengthen regulatory and quality control authority to ensure that all reef construction:

- has environmental and fisheries enhancement objectives consistent with this plan;
- minimizes effects on and conflicts with existing fisheries and uses;
- minimizes impacts on other natural resources and their future use;
- uses materials that have long-term compatibility with the marine environment and related organisms; and
- is subsequently monitored to determine if it meets the original enhancement objectives.

The Department's Division of Fish and Wildlife is charged with managing that State's marine fishery resources. As such, the Division is responsible for the construction of artificial reefs in both the ocean and estuarine waters of New Jersey (that is, within 3 nautical miles of New Jersey's coast). Currently, the Department holds 14 permits for the construction of artificial reefs in State waters.

Artificial Reef construction in Federal waters (that is, beyond 3 nautical miles from New Jersey's coast) requires the issuance of a Federal permit, and is therefore subject to Federal Consistency. Federal consistency is the Federal Coastal Zone Management requirement that Federal actions that have reasonably foreseeable effects on any land or water use or natural resource of the coastal zone be consistent with the enforceable policies of a State's Federally approved Coastal Management Program. In the case of artificial reef construction, the "federal action" is the issuance of a Federal permit for the construction of an artificial reef in Federal waters. Hence, the construction of an artificial reef off the coast of New Jersey in Federal waters must be consistent with New Jersey's enforceable policies, the Coastal Zone Management rules, N.J.A.C. 7:7E. In addition to complying with the applicable sections of the Coastal Zone management rules,

applicants for the construction of artificial reefs in Federal waters shall also demonstrate that they have the necessary funding and administrative capabilities to plan, build, manage, maintain and assume all of the liabilities associated with reef construction in accordance with this plan, the national Artificial Reef Plan and the National Fishing Enhancement Act.

DEP is in the best position to be the coordinating agency for New Jersey artificial reefs because it can better respond to the needs of the general public and has established mechanisms for interfacing with Federal and regional authorities. Turner, et al., (1969) supported this philosophy by stating "Although funding may be from public subscription, federal or state conservation agencies must be actively involved in each reef's construction. Other groups, no matter how well intended, are all too prone to consider only their own special interests. Without basing a reef's construction on proper scientific parameters, it becomes at best a temporary high relief area of questionable value, or at worst an ocean junk pile whose major value has been a promotional gimmick publicizing a special interest group." This sentiment has been followed along the Atlantic and Gulf coasts, where private reef permit holders have transferred their permits to the states which now control virtually every reef program except those of Florida, which are headed by county government agencies.

While strict standards on design and placement of materials along with State oversight and monitoring may discourage private retention of reef permits, DEP will encourage the active participation of private organizations and companies in constructing or adding to reefs under State permits if construction conforms to standards outlined in this plan. DEP will coordinate reef-building activities with private organizations, contractors and government agencies, such as the ACOE and the USCG. It will also assume the administrative aspects of the program described in the following sections and will be a central coordinator for all artificial reef-building activities in New Jersey waters. As a clearinghouse, DEP's F & W will be a repository and disseminator of information pertinent to reef construction and management activities.

5.1 Permit Administration

For each reef site it plans to build, DEP will prepare applications for reef siting and construction permits to the specifications of the regulatory agencies. It will compile and retain a detailed list of all permits, permit requirements, and other approvals required by the ACOE, USCG, EPA, National Ocean Survey (NOS), National Marine Fisheries Service (NMFS)

and other government agencies for siting and constructing artificial reefs. It will also develop and maintain procedures for obtaining and renewing permits and approvals.

Permit applications may need to address provisions of federal acts, such as the Rivers and Harbors Act, the Clean Water Act, the National Fishing Enhancement Act and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). For example, under MSFCMA, the Essential Fish Habitat (EFH) provisions require that the potential adverse effects of a proposed project on federally-managed marine fish and shellfish species be assessed in the permit application. Applicants must request a determination from NMFS and address all agency concerns regarding the potential effects of the project on EFH.

5.2 Contract Administration

When required, DEP will draft Requests for Bids from private contractors for services, equipment, and supplies needed for the program. DEP will maintain lists of contractors and suppliers who can support artificial reef activities and will coordinate the efforts of these groups during their subsequent participation in reef-building activities.

5.3 Materials Acquisition

DEP's F & W will act as a central contact for potential donors of artificial reef materials. DEP personnel will assess offered materials to determine if they meet program standards (Section 6.2). Reef materials will be evaluated on the following criteria: availability, preparation requirements, transportation requirements, physical and chemical stability, biological effectiveness, and net cost. After assessment, DEP will either: (1) accept the material, as is, and follow through on the acquisition; (2) accept the material based on contingencies, such as additional cleaning or modification; or (3) reject offers of materials that do not meet standards or would not make quality habitat. When material is accepted, DEP will help coordinate the legal aspects of the donation, such as turning a vessel title over to the State, or furnishing the donor with written proof of the donation for tax purposes.

Artificial reef materials will be solicited from public and private donors through personal contacts, news releases, or other publicity programs that will stimulate donations. DEP will maintain a list of potential donors

and their materials. If material needs of the program are not met through donations, they may be purchased through appropriate sources.

5.4 Funding

A successful reef program demands a sizable and consistent source of funding for high-quality construction materials and for long-term costs of maintenance, monitoring, and management. A study conducted in 1993 and 1994, found that an average of $2.2 million was spent annually from all sources on all aspects of New Jersey's Reef Program (Brown and Figley, 1995). With a limited budget allocated to the program by the State, reef building activities are primarily dependent upon contributions from a variety of private organizations and government agencies.

5.4.1. State Funds

A limited State appropriation to F & W is used to cover a portion of the salaries of Reef Program personnel. In 1993 and 1994, this direct appropriation represented only about 2 percent of the overall cost of the Reef Program. State funds are used to match Federal Sport Fish Restoration Program Funds ($1 State: $3 Federal). The combination of State and federal funds covers the DEP's F & W personnel expenses, the research vessel and equipment needed to coordinate and supervise all reef-building activities, to conduct surveys and to complete all of the administrative aspects of the program.

5.4.2 Department of Corrections Funds

The labor and supervision of an inmate crew fabricating concrete reef habitats at Southern State Correctional Facility (a State prison) is funded through a state appropriation from the Department of Corrections. A portion of these funds are used to match a Federal Sport Fish Restoration Program grant that covers the costs of concrete and barge transportation for the prefabricated units.

5.4.3 National Guard Funds

During 1994-1999, the New Jersey Army National Guard obtained military funds to clean, prepare and deploy obsolete army tanks on ocean reefs. However, this program was terminated in 2000 due to the cessation of federal funding.

5.4.4 Other State Funds

Short-term grants have been available in the past from the Division of Solid Waste and may be available from other agencies in the future to do specific feasibility studies for reef building.

5.4.5 County Funds

During the past 15 years, Ocean, Atlantic and Cape May counties have allocated tax monies to construct reef units from car tires discarded by their residents. State recycling grants were also applied to these programs. However, after DEP discontinued the use of tires in 1998, all county tire reef programs were terminated.

5.4.6 Federal Funds

Federal Sport Fish Restoration Program funds administered by the U.S. Fish and Wildlife Service are raised through national excise taxes on sportfishing equipment and motorboat gasoline and then distributed back to states to implement recreational fisheries programs. Such funds require a one-quarter match from the participating state.

These federal funds are used by F & W to administer its Reef Program by covering the costs of State personnel, a research vessel, field, lab and office equipment, and travel expenses. During 1993 and 1994, Federal Sport Fish Restoration Program funds accounted for 7 percent of the Reef Program's construction and monitoring efforts. Between 1984 and 1997, such funds were used only once for actual construction activities; in that case, to prepare and sink the USS Algol, a 460-foot navy transport ship. Since 1998, however, a project to build and deploy prefabricated concrete reef habitats has been financed by Sport Fish Restoration Program Funds.

5.4.7 Military Funds

The U.S. military forces, including the Coast Guard, Navy and Army, have participated in New Jersey's Reef Program in many ways. The Coast Guard provides security vessels during reef deployments and has prepared and sunk several obsolete USCG vessels on reefs. The Navy has also funded the cleaning of several tankers destined for sinking on reefs. The Navy has supplied demolition teams and obsolete vessels for sinking. The army funds operation REEFEX, which prepares and deploys obsolete army

vehicles on reefs. The Army Transportation Corps has supported the program by towing several vessels to ocean reefs. All of the operations are considered training exercises and are thus covered by military funding. The ACOE has used the Sandy Hook Reef as a depository for millions of cubic yards of rock that were dredged to deepen New York Harbor. The expense of barging the rock to the reef was a budgeted component of the ACOE project.

5.4.8 Corporate Donations

Demolition concrete is delivered to the reefs at the contractor's expense. As a rule, this is only done when the contractor is saving money over other disposal or recycling alternatives. Over the years, many demolition contractors have contributed concrete material for reefs.

Obsolete ships and barges are usually donated to the program by their owners. However, because of competition from salvage yards, it is often necessary to defray a portion of the cleaning and towing costs to make it cost-effective for the donor. These accessory funds are provided from private donations.

5.4.9 Private Donations

Private donations are primarily used to help offset the costs of cleaning and towing vessels to reef sites. Private donations are obtained in a variety of ways, including:

- from private companies seeking recognition or advertising;
- from fishing and diving clubs;
- as purchases of fund-raising items;
- as Adopt-A-Wreck donors, who get to name the reef sponsored by their donation.
- In 1992 a private, non-profit organization, called the Artificial Reef Association (ARA), was formed by a group of party and charter boat captains for the sole purpose of raising money to help build ocean reefs. All funds raised through the various forms of donations are held in a

bank account, called the Sportfish Fund, which is administered by the Fisherman Magazine. As expenses are incurred, checks are disbursed from this account.

While private donations of money represent less than 5 percent of the annual reef-building expenses, they provide the Reef Program with a flexible and timely means of hiring professional services to perform the accessory tasks, such as bilge cleaning or towing, needed to complete a reef-building project.

5.5 Jurisdiction over Fisheries

Because of the State's jurisdiction in its estuarine waters and territorial sea, DEP has made significant strides in managing the harvest of marine species by enacting laws, governing size limits, harvest and possession limits, seasons, harvest areas, and gear types. However, the State lacks the necessary jurisdiction to manage harvests from fisheries that occur on artificial reefs located beyond the three-mile limit; it cannot control fishing gear, methods, limits nor seasons, nor any other uses of reefs in those waters. This lack of authority has become one of the principal problems plaguing states with artificial reef programs. Ansley (1981) asserted, "A final solution to reef use problems is regulation, involving the imposition of harvest limits, gear restrictions, and/or restricted entry. With increasing pressure and decreasing funds for reef construction, managers have to consider this tactic as a viable alternative when dealing with problems of pressure/demand and user group conflicts." He went on to say, "At this point in time many programs choose to avoid the question of regulation because of its volatile and political nature."

5.5.1 Special Management Zones

The Mid-Atlantic Fishery Management Council (MAFMC) has the authority within the Summer Flounder, Scup and Black Sea Bass Fishery Management Plan to enact specific fishing gear restrictions around artificial reefs. The restricted areas have been termed Special Management Zones (SMZs). In 1985, the South Atlantic Fishery Management Council (SAFMC) assumed authority for instituting SMZs as part of the Snapper-Grouper Fishery Management Plan. South Carolina applied to the SAFMC and received SMZ classification for many of its reef sites. Gear restrictions imposed through the SMZ included a prohibition of fish traps and powerheads (explosive tips) on spears. SMZ authority currently applies only to fishing gear and does not permit regulation of fish size, harvest or season.

To obtain SMZ status for New Jersey reefs in federal waters, DEP must apply to the MAFMC. Such proposals will be evaluated by a MAFMC review committee. If approved, the management measures would be adopted by the MAFMC and not by the State of New Jersey.

5.6 Mitigation

Throughout the United States, artificial reefs have been used in isolated cases to mitigate the loss of marine habitats or marine life. In rare cases, the mitigation was in-kind, involving the replacement of a damaged natural reef with a nearby artificial reef. More often, however, mitigation is off-site and involves non-reef habitats, such as the creation of an ocean reef to mitigate loss of shallow-water, estuarine habitat.

DEP supports the creation of artificial reefs for in-kind, near-site mitigation. The use of artificial reefs for non-reef habitat, non-reef marine life or no-other-option mitigation should be determined on a case-by-case basis by a consensus of the environmental agencies reviewing the action.

Once directed, DEP will develop a reef construction program equal to the approximate level of mitigation required. This process could be facilitated by using specially-designed reef habitats with measurable dimensions and quantifiable marine life communities associated with them.

5.7 Library Administration

DEP's F & W retains extensive paper files of documents, legal agreements and correspondence concerning the administration of all aspects of the Reef Program, including State and Federal permits and applications, material inspection and deployment logs, expense vouchers, news releases, and contractual agreements. This historical information is invaluable in documenting accomplishments of the Reef Program and settling controversies.

F & W maintains a technical library of artificial reef publications and unpublished state reports, particularly those relative to reef technology, research and legal issues. It also has extensive photo, slide and video files that illustrate artificial reef activities. News clippings of reef activities published in magazines and newspapers are also saved. Professional

photographers have been enlisted to provide underwater photos of reef and wreck marine life. Each vessel sinking and research project is documented photographically. An archive of side scan sonar surveys of reef sites and structures is also maintained.

5.8 Economic Analyses

To determine the economic value, impact and cost-effectiveness of New Jersey's artificial reefs in terms of recreational fisheries and scuba diving activities, DEP will follow guidelines established by the Artificial Reef Development Center (Bockstael, et al., 1985), which are consistent with the NMFS Guidelines for Economic Valuation of Marine Recreational Fishing (Huppert, 1983). Guidelines suggest the following series of steps to take for assessing the values of artificial reefs:

(1.) Obtain an assessment of the specific short and long-term changes in the sportfishing environment which will result from introduction of an artificial reef.

(2.) Obtain a preliminary assessment of the specific sportfishing or diving activity in the area.

(3.) Select a valuation approach for estimating non-market benefits of reefs.

(4.) Launch a data collection effort to provide information for the selected approaches.

Thus far, New Jersey has conducted the following economic surveys of recreational fishing and diving activities: Analyses of expenditures by New Jersey recreational wreck anglers and divers (Brown and Figley, 1992); and the costs of building and managing the State's reefs (Brown and Figley, 1995). Such studies have not only provided insight into the costs of building New Jersey's reefs, but also the economic benefits derived through such efforts.

Information concerning the economic value of commercial fisheries on reefs or reef-associated species can be obtained from commercial landing statistics compiled by NMFS. Dockside values can then be extrapolated using industry multipliers to determine the total economic value of the product as it passes through seafood markets or restaurants to the consumer.

5.9 Biological Analyses

DEP will plan and implement biological monitoring programs (Section 6.5) using proven methodologies for determining the productivity and benefits of an enhanced fishery. Such studies will help determine the best materials, unit designs and artificial reef configurations for achieving project goals. New strategies and objectives will be developed if monitoring reveals shortcomings in the reef program.

5.10 Information Distribution

According to Merriner (1981), "Assessment, evaluation, promotion, and education are not luxuries in a reef program. We have to tell the public, administrators, our fiscal and moral sponsors, our civic groups, and our users what the program is to do, why, and for whom it exists, and how long it will take the program to accomplish its stated goals. We have to identify program accomplishments in terms of biological resources and dollars generated in the local economy for both commercial and recreational users. We then identify the present and project needs so that the reef program can generate greater public benefits and compete for public funds. Then we recommend a program to accomplish these goals within the respective jurisdictions in which we work."

DEP disseminates information about the Reef Program to reef users and the general public through an annual newsletter (25,000 copies), articles in the Marine Issue of the Fish and Wildlife Digest (175,000 copies annually), press releases, reef charts, films, television programs, magazine articles, seminars and slide presentations and an Internet Website. The news media is invited to inspect land-based operations to get first-hand views; observation boats are often chartered to provide media coverage of reef deployments. The following books have been published to inform the public about DEP's reef-building efforts:

- A Guide to Fishing and Diving New Jersey's Artificial Reefs (Figley, Preim and Perrone 1989, Preim, Carlson and Figley 2000)

- The Shipwrecks of New Jersey's reefs (Carlson, Preim and Figley 2003)

Information is transmitted to the scientific community through technical reports and participation in regional, national and international reef conferences. New Jersey is a voting member of the ASMFC's Reef Committee and attends biannual meetings of the committee. Such meetings

facilitate the exchange of current information and experience regarding reef management and construction among Atlantic coast states.

6.0 ARTIFICIAL REEF MANAGEMENT AND MAINTENANCE

6.1 Site Selection

The parameters listed in the following sections are considered in the selection of ocean reef sites. The selection process utilizes exclusionary mapping, a method developed by the Artificial Reef Development Center to exclude poor locations for building reefs and select optimum areas (Myatt and Ditton, 1986). This process delineates major population centers, geographic areas of greatest user demand, land and water access points, existing fishing grounds, etc. Where appropriate, the Administration also uses siting guidelines set forth in the National Artificial Reef Plan.

6.1.1 Distance Offshore and to Major Inlets

Most reef sites should be within 15 nautical miles of major inlets, so that they can be easily reached by sport fishermen and divers. Half-day party fishing boats have a very restricted range and rarely venture more than 8 miles from their inlet. In 1995, 93.6, 84.1 and 88.9 percent of private, charter and party boat wreck fishing trips, respectively, were within 15 miles of shore (Table 7; Figley, 1996).

The establishment of distant deepwater reefs (over 15 miles offshore) allows the Reef Program to accept large vessels with high vertical profiles. While offshore sites will not be used as intensively as inshore reefs, the deeper sites will offer different fishing opportunities, such as for cod, pollock, tuna and sharks, than the shallower ones.

6.1.2 Depth

The depth of a reef site is critical because the ACOE and U.S. Coast Guard specify the clearance that is required over the top of a reef structure to ensure safe navigation. Clearance is measured from the ocean surface at low tide to the top of a reef. In most cases, ACOE requires 50 feet of clearance on New Jersey reefs. A variance from the normal amount of clearance may be requested if a site is surrounded by a series of navigational hazards, such as shoals or shipwrecks. In this case, a reduced clearance requirement (30’ or 40’) between the top of the proposed artificial reef material and the ocean surface may be appropriate because the reef would not present an additional area of hazard.

Table 7. Distance traveled offshore to wrecks and reefs by recreational fishing boats during 1995.

Distance Offshore (miles)	Percentage of Trips		
	Private	Charter	Party
0-5	46.1	25.0	33.3
6-10	39.6	38.6	31.5
11-15	7.9	20.5	24.1
16-20	1.3	13.6	9.3
21-25	-	2.3	1.9
26-30	2.6	-	-
over 30	2.6	-	-

6.1.3 Substrate Types

A hard sand, sand and clay, gravel or shell substrate is preferred to support large reef structures; these bottom types, common off New Jersey, reduce subsidence and increase the lifespan of reef materials as habitats. Areas with soft, muddy bottoms will be avoided because reef materials may sink too deeply and lose their usefulness as fish habitat.

6.1.4 Biological Factors

Reefs will be constructed in areas that are biologically productive. However, sea floor areas that have traditionally been highly productive, such as sand ridges (e.g., Barnegat Ridge) or rock outcroppings (e.g., Shrewsbury Rocks) will be avoided. Site selection will be based partly on interviews with sport and commercial fishermen and partly on scientific surveys. Experienced local fishermen can provide information regarding catch rates on existing wrecks in the vicinity of a proposed reef site. From a practical view, it is more efficient to place a reef intended for hook and line fishing near a reportedly good fishing area. However, scientific surveys, such as those conducted by Hueckel and Buckley (1982), will also help in the selection of sites. These researchers tested each potential reef site through in situ examinations to identify fish, invertebrates and algae and determine biological diversity. Special attention was given to any solid substrate in the area. Organisms on such substrate were considered indicators of the species that would eventually occur on reefs placed in the same areas.

6.1.5 Conflict with Commercial Fisheries

Current commercially important trawling and sea clam or sea scallop dredging grounds will be avoided for reef construction. Areas historically avoided by these mobile fisheries, such as former fish havens and existing wrecks, will be selected where they meet other site selection criteria. Site boundaries will be oriented along latitude-longitude lines, where possible, to help commercial otter trawl and dredge vessels avoid reef sites. Efforts will be made by DEP to notify the commercial fishing industry of reef sites with bulletins, news releases and direct mailings. All reef sites are now clearly delineated on NOAA nautical charts.

6.1.6 Shipping Lanes

Reefs will not be constructed within charted shipping lanes and anchorages, as defined by OCS/NOAA navigational charts. USCG guidelines regarding navigational obstructions will be followed.

6.1.7 Pipelines and Cable Crossings

Reefs will not be constructed within pipeline or cable corridors (one nautical mile buffer on either side of the line) as defined by OCS/NOAA nautical charts.

6.1.8 Water Quality

Ocean areas known to commonly experience hypoxia (reduced dissolved oxygen levels) or near sewage outfalls or historical disposal sites, such as for dredge spoil, will be avoided.

6.1.9 Currents

Ocean areas where currents routinely exceed two knots will be avoided for reef construction because of potential material instability, scouring, or sanding over. Current information can be obtained from published tidal current tables. Local knowledge and on-site monitoring will be used when additional information is required about a particular location.

6.1.10 Coastal Zone Management rules

To reduce conflicts amount ocean uses and to protect significant marine resources new artificial reefs shall not be located in the following special areas: surf clams (N.J.A.C. 7:7E-3.3), prime fishing areas (N.J.AC. 7:71E-3.4), navigation channels (N.J.A.C. 7:7E-3.7), inlets (N.J.A.C. 7:7E-3.9), submerged infrastructure routes (N.J.A.C. 7:7E-3.12), and historic and archaeological resources (N.J.A.C. 7:7E-3.36).

6.2 Construction Materials

Since 1984, DEP has used a variety of donated materials to build over 2,100 patch reefs out of 3.3 million cubic yards of material (Figure 9). Rock represents the vast majority of reef materials, accounting for 82 percent of the total volume, followed by ships and barges (9 percent), concrete

(7 percent), and all other materials combined (2 percent). These materials included:

- rock
- concrete demolition material
- concrete pipes
- steel demolition material
- steel-armored undersea telecommunications cable
- concrete-ballasted tire units
- steel ships and barges
- wooden ships
- fiberglass boat hull mold
- obsolete army tank
- flatbed rail cars
- subway cars

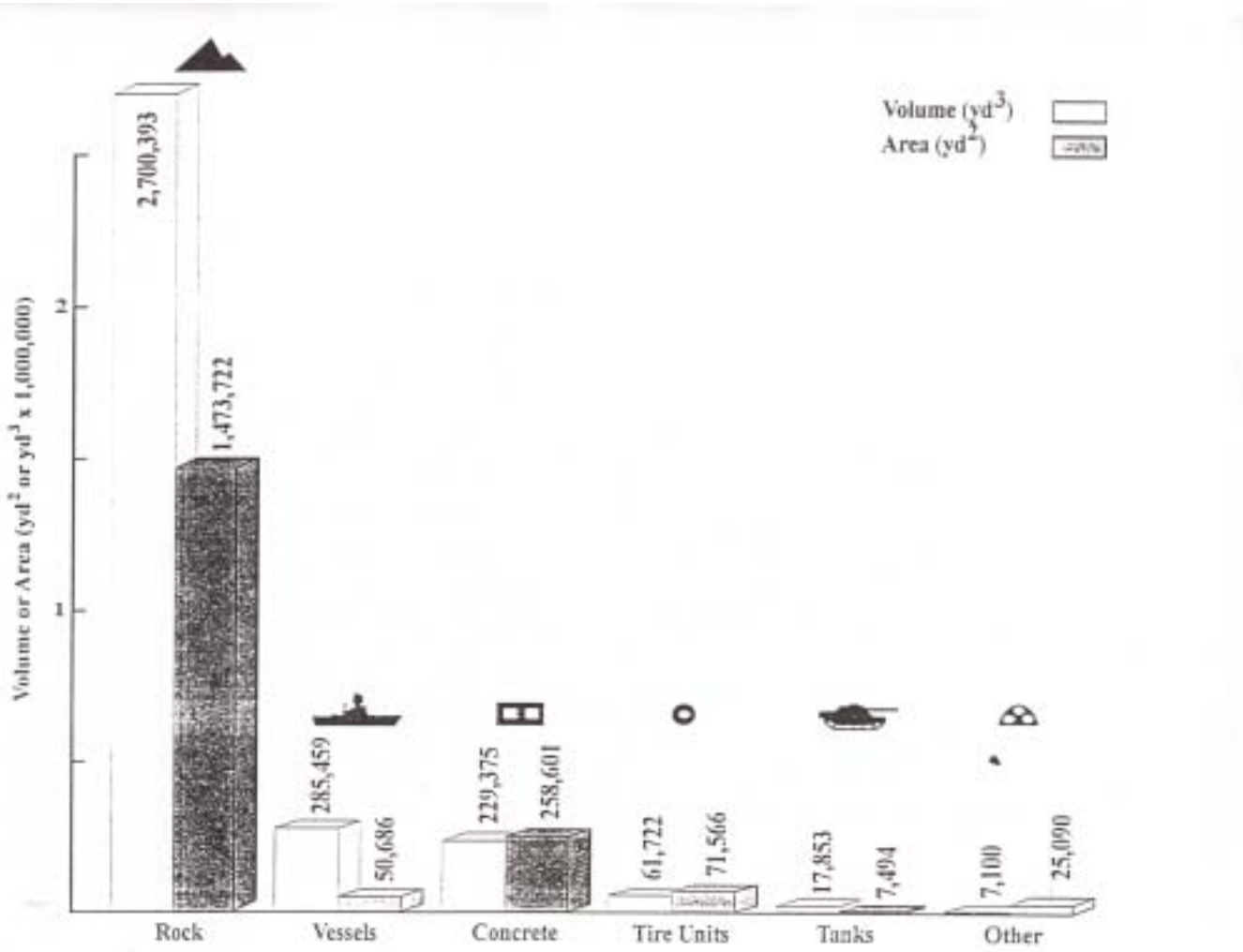


Figure 9. The volume and area of reef structures placed in NJ reefs through December, 2002

Worldwide experience has demonstrated that only reef structures consisting entirely of dense materials can be used to build stable and durable reefs (Lukens 1997). Dense materials include rock, concrete and steel (and heavy gauge aluminum). Lightweight materials, such as wood, fiberglass and tires, are unacceptable and are no longer used to build reefs.

Reef structures are not expected to last forever. The destructive properties of the ocean – storm surge, scouring, corrosion, chemical replacements, electrolysis and sand-blasting- work continuously to reduce the life-span of both man-made and natural reef materials. Even rocks which degrade very slowly in the ocean, can quickly sink in just a few years under the sand and lose their effectiveness as reef structures. The calcium carbonate binder in cement is replaced by sulfates and magnesium ions in seawater, leading to weakened concrete and deterioration. Type II Portland cement, which is used to manufacture Reef Ball habitats, can be expected to have a life expectancy of 20 to 35 years in the marine environment (American Society of Testing Materials in the Designation Standard Specifications for Portland Cement). Over time, all steel structures slowly disintegrate due to corrosion and electrolysis in sea water.

Sections 6.2.1 to 6.2.8 describe materials that are now being used to construct artificial reefs in New Jersey. However, the continued long-term use of these materials will depend upon careful evaluation of their suitability on each reef site.

6.2.1 Concrete and Steel Construction Material

Concrete and steel construction material from demolished buildings, piers, highways, bridges, etc. may be accepted as reef material if the majority by bulk is in large chunks (cobblestone or greater) and does not contain floatable materials, toxic residue or large volumes of dirt. To ensure that the material meets these criteria, each proposed source is inspected by F & W personnel prior to its transport to sea. All costs of preparing, barging and deploying concrete construction material will be covered by the contractor.

6.2.2 Rock

The dredging of New York Harbor has provided millions of tons of rock for reef construction. The bedrock is blasted into pieces that range in size from chips to cobblestones to boulders the size of automobiles. The rock should contain only limited amounts of fine-grained silt, mud or clay, comprising less that 10 percent of the overall volume of the load. Rock mixed with a matrix of sand, gravel or pebbles is acceptable.

6.2.3 Ships and barges

Only aluminum or steel-hulled ships and barges are acceptable for reef deployment. Wooden, fiberglass or ferro-cement vessels will not be accepted because of their history of instability on the sea floor; ACOE reef permits prohibit their use in New Jersey. Each vessel will be individually judged to ascertain its usefulness as a reef.

Factors to consider before accepting donated vessels for the reef program include seaworthiness, durability, stability, suitability for particular reef sites and the costs of cleaning, preparing and towing. A large vessel with tall profile, such as a liberty ship, is not acceptable for a shallow, inshore reef, but may be suitable for an offshore reef in deep water. Procedures for vessel preparation and sinking are discussed in Section 6.4.3.

6.2.4 Armored Military Vehicles

Armored military vehicles, such as tanks and personnel carriers, are similar to ships and barges, consisting of steel hulls, fuel tanks and engines. Thus, they present similar cleaning and preparation procedures. Lightweight vehicles, such as jeeps and trucks, are unacceptable due to their instability and short lifespan on the ocean.

6.2.5 Railway Cars

Passenger, subway, tanker, hopper and flatbed railroad cars have been used by several states as reef material. Their cleaning and preparation is similar to that of vessels and armored military vehicles. If wheel carriages are removed, only minor components of these cars need to be cleaned or removed. The assistance of the USCG and EPA was enlisted

to develop a protocol for cleaning and preparing New York City Transit Authority subway cars.

The approval to use subway cars in 2003 to build ocean reefs and their subsequent evaluation is covered under the Commissioner's Policy Directive 2003-02 (Appendix A) as follows:

1. The Office of Natural and Historic Resources (NHR) shall proceed to arrange the placement of a total of up to 250 subway cars, distributed among five currently designated reef sites at Garden State North, Atlantic City, Cape May, Shark River and Deep Water (off Ocean City). These placements occurred July through September, 2003.

2. As authorized in the Directive, "DEP shall establish a program of monitoring these sites for eight years; to ascertain any impacts and to ascertain the structural integrity and durability of the material and its efficacy in providing habitat in each marine environment. The program shall conclude in a report to the Commissioner subject to public notice and comment. To develop the report, DEP shall initiate a balanced and independent scientific and technical reef advisory committee (TRAC), made of regional reef ecologists and scientists from relevant interests, including the National Marine Fisheries Service, EPA, other State agencies and NJDEP F & W, fisheries and marine ecosystem experts, and academia. The TRAC will develop and follow monitoring requirements and plans for an eight-year study to include, but not limited to:

- monitoring potential asbestos impacts to sediments and biota, with three offsite controls. Samples will be collected and tested every two years over an eight-year period.

- Monitoring of durability and stability of subway cars

- conducting a comparative fisheries productivity and diversity assessment to other reef materials; and

- recommending procedures for contingencies should adverse effects from the asbestos materials be found.

At the end of the eight-year study, the TRAC will review the data and make a determination on whether the subway cars meet the

standard set forth in paragraph 4 and make further recommendations for artificial reef standards, if needed The TRAC shall submit progress reports annually."

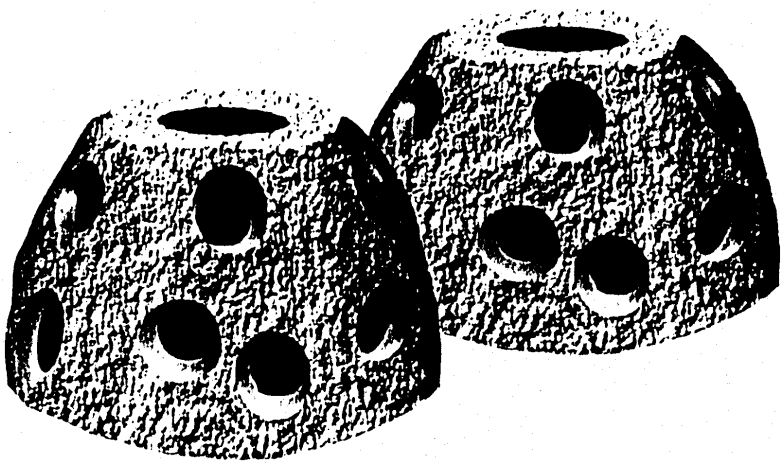
6.2.6 Undersea Telecommunications Cable

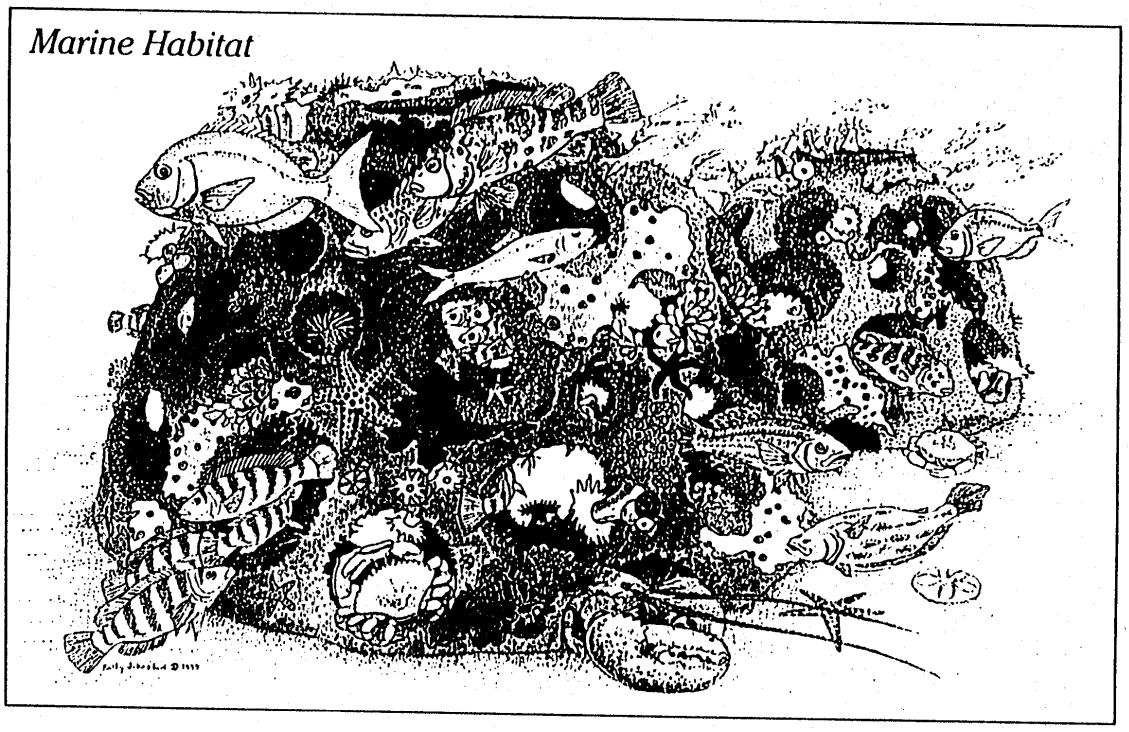
Undersea telecommunications cables are very heavy gauge (2”-3” in diameter and weighing up to 6 pounds per linear foot) cables which consist of a central communications wire surrounded by heavy gauge steel wire sheathing. After laying on the ocean floor for 50 to 100 years, they show little sign of wear. Since cables stretched across the ocean bottom pose a hazard to commercial trawl nets and dredge, obsolete cables must be removed. When redeployed on reefs in 100’ diameter piles 3’ to 10’ in profile, the interstices created by the overlapping weave of cable provide an excellent fish habitat.

6.2.7 Fabricated Reef Structures

DEP has learned through extensive experience with materials of opportunity that the preferred direction for the future will be to fabricate reef units from concrete or steel (an example is shown in Figure 10). Lightweight materials, such as plastic or fiberglass, are unacceptable as major components of reef structures, and therefore, will not be used to build designed reef structures. Imperfect concrete castings include large-diameter pipe, junction boxes and other hollow concrete structures that are unsaleable, due to cracks or chips. Since they closely resemble designed reef structures, they can be considered as such. Advantages of prefabricated units include the ability to control the design and size to maximize their effectiveness as habitats and to avoid the potential problems associated with materials of opportunity. The only drawback is the great expense of manufacturing and transporting such units; thus, the level of funding available to F & W will determine the level of production.

Figure 10. Fabricated reef units made of concrete





6.2.8 Other Suitable Materials

According to Policy Directive 2003-02 (Appendix A), any new artificial reef materials, with the exception of subway cars, must meet a standard of "retaining a minimum of 90 percent of original structural integrity for 30 or more years." Currently, there is no federal standard, but the National Plan states that artificial reef materials must be resistant to deterioration and breakup. The Directive further requires that materials made of structural steel must exceed 0.25 inches in thickness. New materials will be evaluated by the TRAC and ACOE.

6.2.9 Materials Prohibited for Reef Construction

Based on experience worldwide, the division has the following list of materials are **PROHIBITED** for use in reef construction in New Jersey:

- wooden vessels
- ferro-cement vessels
- fiberglass vessels or hull molds
- railroad box cars
- concrete-ballasted tire units
- automobile and truck bodies
- airplanes
- white goods (i.e. refrigerators, stoves,)

6.3 Reef Configuration and Design

Reef configurations and habitat designs constitute an integral part of the reef program and thus will be carefully planned and scrutinized. A summary of the planned artificial reef network is described in the following

sections. Monitoring of the reefs, discussed in Section 6.5, will suggest means for refining habitat designs and reef configurations to obtain maximum benefits for marine life and reef users.

6.3.1 Artificial Reef Network

From an organizational viewpoint, the reef network represents all of New Jersey's ocean reef sites, spanning the coast from Sandy Hook south to Cape May (Table 6). By 2000, this network included 14 reef sites approximately evenly spaced to provide access from each of the State's ocean inlets. The network has been planned so that each inlet has access to two or more inshore reefs and one offshore reef. A deepwater reef offshore of Barnegat Inlet is needed to complete the network. In total, New Jersey's reef network occupies 24.6 square nautical miles of sea floor, out of a total of 8,750 square miles of sea floor off New Jersey to the edge of the continental shelf.

6.3.2 Artificial Reef Sites

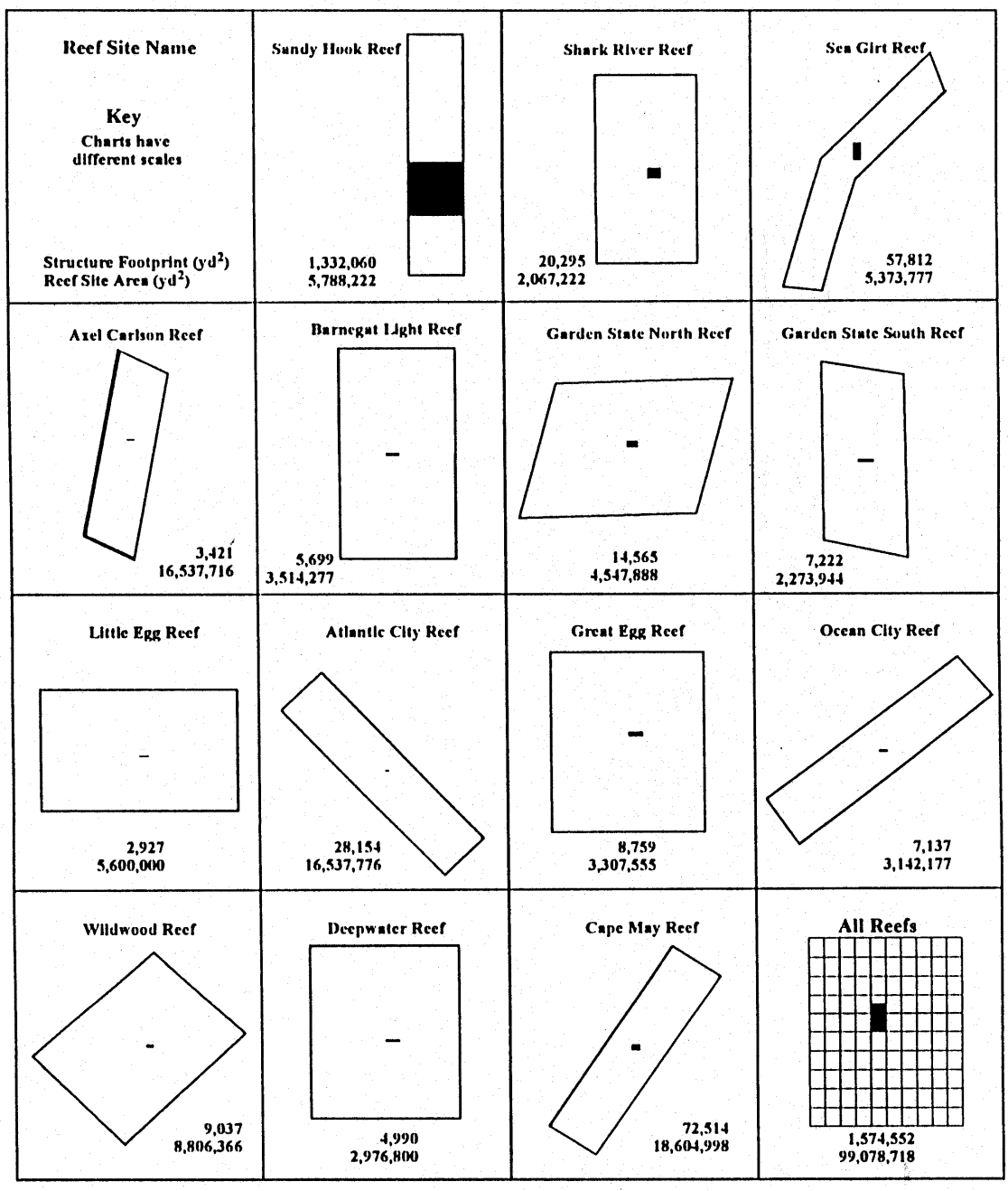
Reef sites are defined areas of the ocean bottom documented on ACOE permits (see Appendix B). They are often termed "artificial reefs" or "fish havens" instead of "reef sites" and are delineated on NOAA nautical charts with light blue shading.

After 19 years of reef construction efforts, 0.5 square nautical miles of sea floor have been covered by reef structures; this represents only 1.6 percent of the 24.6 square miles permitted as reef sites, for a construction rate of about 0.1 percent coverage of reef site sea floor with reef structure per year (Figures 7 and 11).

6.3.3 Patch Reefs

Large numbers of patch reefs, usually called "reefs", will be constructed on each reef site. Patch reefs are several-square-yard to several-acre reefs created by placing a single structure, like an army tank or barge, or a barge load of material in one area. Patch reefs are identified on reef charts by a single icon and located by a single navigational coordinate (see Appendix B).

Figure 11. Reef structure footprint, January 1, 2002



A large number of small patch reefs within a reef site, separated from one another by expanses of open bottom, are superior to a single large reef. This method of reef site development is undertaken to achieve the following ecological and socio-economic benefits:

(1) the combination of open sand and reef habitats results in more biologically productive reefs (Turner et al. 1969; Lindberg 1996), by:

(a) increasing the "edge effect" between habitats, where species diversity and abundance is typically greater than that found in either habitat (Odum 1953);

(b) increasing the surface area of reef habitat available for colonization by fouling organisms;

(c) providing an interspersion off reef and sand-bottom habitats, which enables mobile species to take advantage of both habitats, e.g. some fish species that use reefs as shelters from predation, feed on the sandy bottom;

(2) a large number of small patch reef habitats spreads out fishery resources, thus reducing the harvest of marine life:

(3) a large number of patch reefs allows a greater number of divers and anglers to use a reef site simultaneously and;

(4) dispersed patch reefs spread out reef users, thus reducing conflicts among fishermen and divers;

6.3.4 Artificial Reef Units

An artificial reef unit is a structure designed and fabricated specifically for reef habitat. Up until 1997, concrete-ballasted tire units were the only reef units being used in New Jersey. In 1998, the Division began fabricating designed concrete units, called "Reef Balls", which resemble small igloos with many access holes. Reef units are small, 1 to 2 cubic yards in volume, and can either be deployed in groups to create fishing spots for anchored boats, dispersed in large, but defined, areas in concentrations dense enough to provide drift fishing or dispersed so far apart that they discourage angling, and instead, act as micro-refuges for fish and shellfish production.

6.4 Material Preparation and Deployment Procedures

Division personnel will oversee and coordinate all aspects of reef material preparation and reef construction. While the policies and procedures for each type of material will vary, the overall objective of providing clean, durable, safe and stable structures for reef construction will be maintained.

Division personnel will notify the ACOE and USCG of their intent to place materials on a reef site and will be present during material unloading to verify that it was placed according to permit specifications.

Post-deployment site inspections will be performed after each patch reef is deployed. The inspection will entail: 1) recording LORAN C and DGPS coordinates of the new material in a log; 2) recording a sonar relief plot of vessels; and 3) if warranted, performing a diving inspection to ensure permit or contractual compliance and to record visual details that can be relayed to reef users. The assistance of reliable, volunteer divers may be enlisted to perform underwater investigations.

6.4.1 Concrete and Steel Construction Material

To ensure that concrete and steel demolition materials do not contain floatable or lightweight materials or hazardous components, all prospective demolition projects will be inspected prior to deployment, either at the job site or on the barge at the docksite. To further ensure that floatables are not released at sea, an observation boat with a F & W observer onboard will follow the tug and barge on the reef site during deployment. The deployment will be terminated if floatables are released into the water.

6.4.2 Ships and Barges

Ships and barges will be prepared and sunk in the following manner:

(1.) clean or remove engines, generators, filters, machinery, and fuel tanks;

(2.) remove all floatable materials, pollutants, and batteries;

(3.) obtain USCG pollution inspection and approval;

(4.) vent all watertight compartments;

(5.) seal all through-hull vents for transit to reef site;

(6.) ballast with concrete when needed to ensure stability;

(7.) weld either open or shut or remove all hatches and doors;

(8.) if necessary, cut down superstructure that may exceed navigational clearance requirements;

(9.) place auxiliary pumps onboard, if needed, (in case of flooding) and tow to reef site;

(10.) either anchor vessel on reef site or hold in position with tug;

(11.) sink either by opening seacocks by cutting holes in the hull and pumping in water, or by blasting holes in the hull. To prevent excessive damage, loss of habitat and possible fish mortality, minimal explosive charges will be used;

(12.) if necessary, after the vessel sinks, clean area of floating debris.

6.4.3 Armored Military Vehicles

Armored Army vehicles are cleaned and prepared at Fort Dix by the New Jersey Army National Guard following a step-by-step protocol developed by the U.S. EPA Region II. While the protocol differs slightly among the various vehicle types, the basic procedure is to:

(1.) demilitarize any weapons;

(2.) remove engines, transmissions, hydraulic systems, batteries, and floatables;

(3.) drain or if possible, remove fuel tanks;

(4.) weld hatches open or shut;

(5.) pressure wash.

After cleaning, each vehicle is inspected by F & W personnel. Deployment on reef sites is accomplished by pushing tanks off a flat deck barge with a bulldozer. An observation boat with F & W personnel onboard follows behind the barge to direct offloading and obtain precise deployment coordinates.

A new protocol for cleaning and preparation must be developed and approved by the U.S. EPA for each new type of armored vehicle brought into the program.

6.4.4 Rock

To date, the only source of rock for the Reef Program has been from ACOE channel dredging projects from the Ports of New York and New Jersey. The ACOE contracts dredging companies that are responsible for transporting and deploying the rock on the Sandy Hook Reef site. Rock is delivered in large dump scows capable of carrying 6,000 to 12,000 tons of rock. The barges open up along their midline, dropping all of the material in a single, long pile. F & W supplies the tug captains with data logs that specify a target site on the reef to drop the rock. Each tug and barge is equipped with a navigational computer that monitors the trip and records the exact location where the rock is dropped. A record of each trip is sent to F & W following deployment.

6.4.5 Undersea Telecommunications Cable

As pieces of obsolete steel-armored telecommunications cable are recovered from the sea floor they are spliced together and rolled onto a drum. The “repeaters”, which may contain PCBs are removed and recycled. The cable is deployed from a stationary vessel by unspooling the wire onto a confined pile (approximately 100 feet in diameter) on the seafloor. Since cable can snag anchors, all cable deployments will be restricted to a one-square-mile "drift fishing area" of the Atlantic City Reef Site.

6.5 Monitoring Programs

The New Jersey Reef Program will monitor reefs after construction to conform with guidelines of the National Artificial Reef Plan, which

describes the two following reasons for establishing monitoring programs as part of reef management: 1) Compliance Monitoring—to assure compliance with the conditions defined in any authorizing permits or other applicable laws or regulations; and 2) Performance Monitoring—to provide an assessment of the biological, recreational and socio-economic performance of reefs and to assure that the reefs meet the general standards established in Section 203 of the National Fishing Enhancement Act of 1984.

6.5.1 Compliance Monitoring

Unstable reef materials can result in environmental and economical damages and consequently, jeopardize the reef program. For these reasons, DEP places a strong emphasis on material stability and durability assessments.

Based on wave data from the U.S. Weather Service (Jenson, 1983) on the probability of certain wave heights occurring, and on the size of the reef sites involved, F & W believes materials placed on artificial reefs should ideally meet the following stability criteria:

- material should not move from a deployment position in 60 feet of water when subjected to forces generated by waves up to 20 feet high.

- material should not move more than 60 feet from a deployment position in 60 feet of water when subjected to forces generated by waves between 20 and 30 feet high.

The probability of 20-30 foot wave heights occurring in New Jersey's inshore ocean waters is unlikely except possibly during a "100-Year Storm". According to Jenson (1983), maximum wave heights recorded during storms between 1959 and 1979 reached, but did not exceed, 14.9 feet at New Jersey wave stations situated in 33 feet of water; larger waves would be expected from these same storms in deeper, offshore waters. Thus, the primary concern is stability of materials in the more commonly occurring wave forces of less than 20 feet.

To determine how well sunken reef materials have withstood wave forces, one or two reef sites will be surveyed each year with side scan sonar. This device draws a detailed picture of the sea floor showing the locations of all reef structures, even those as small as tire units (Lukens, et al. 1989). By comparing recent side scan tracings with deployment records

and previous side scan surveys, structure movement can be identified. Large structures, such as vessels or tanks, are precisely located with LORAN or DGPS and then, graph recordings of their profiles are obtained with a fathometer. This type of information collected over time can also be used to assess potential movements. If monitoring reveals movement, further deployment of that material will be terminated. All side scan surveys are archived as references for future surveys. It should be noted that side scan has not revealed movement of any reef structures between 1987 and 1999.

Quantitative assessments of both reef structure durability and subsidence (sinking into the sea floor) are obtained through observations by divers. For large structures, such as ships or tanks, fathometric surveys can also provide information on subsidence.

6.5.1.1 Buoys

The U.S. Coast Guard requires that reefs are buoyed unless otherwise exempted. Reef buoys are yellow, which signifies a warning to navigators and commercial fishermen of the presence of sea floor obstructions. While reef sites are not located in charted shipping lanes, lighted buoys may be needed in areas subject to heavy shipping traffic. On artificial reefs, buoys can also aid anglers in finding reef sites and provide a floating advertisement of the reef program. However, buoy costs, deployments, inspections and repairs are time-consuming and very expensive. Furthermore, the lifespan of reef buoys is short, especially with frequent ocean storms. In New Jersey, buoy costs would exceed Reef Program financial assets. Also, fishing boats are now equipped with relatively inexpensive navigational gear which allows precise positioning over reef structures. For these reasons, F & W opted to request exemptions for reef site buoying from the U.S. Coast Guard; the exemptions were accepted and therefore, none of New Jersey's reef sites are marked with buoys.

6.5.2 Performance Monitoring

While there is no limit to the number of questions that can be asked regarding the biological, ecological and socio-economic aspects of artificial reefs, the reality of a limited budget, limited manpower and limited time has forced the Reef Program to both focus its attention on practical management issues and adapt its performance monitoring efforts to what can realistically be attained. Whenever possible, performance monitoring

studies will be designed following standardized methods (Seaman et al., 1992 and Seaman, 2000). The types of information that have been and will be collected and the procedures employed in collecting them are briefly summarized in sections 6.5.2.1 and 6.5.2.2.

6.5.2.1 Biological Assessments

Obtaining an understanding of thorough biological and ecological attributes of artificial reefs is an immense undertaking that will require decades of work by many researchers worldwide. Therefore, DEP will rely heavily on independent studies of other states and their universities to gain insights into the biology and ecology of New Jersey reefs. To maximize it's efforts, DEP will conduct numerous short-term and focused studies, where F&W personnel will perform field collections and various academic institutions will be contracted to perform laboratory analyses. Another approach will be to place small-scale reef structures in clusters where they can be enclosed in mesh bags and brought to the surface for identification of species and quantification of biomass. In this way a more complete look at the reef community and all its members can be examined in miniature over time.

DEP will continue to focus its attentions on the following biological/ecological investigations:

(1) species diversity and standing stock biomass of the following components of the reef community: turf or fouling fauna and flora, mobile epifauna, juvenile fish, and adult fish.

The fouling or turf community can consist of both plants and animal species that attach to reef substrates. This diverse community forms the basic level of the reef food chain and provides protective cover for mobile invertebrates and fish. Mobile epifauna includes crabs, shrimp, worms and other invertebrates that provide a forage base for reef fish. With fish production being a primary objective of the Reef Program, inventories of juvenile fish use of reefs and determinations of the factors that influence their abundance and survival are essential. An understanding of the species diversity and abundance of fish inhabiting artificial reefs is needed to manage fisheries, assess the effectiveness of reef-building activities and evaluate the relative value of different reef structures.

(2) Food web relationships of important reef fish and macroinvertebrates

The analysis of stomach contents provides information on the feeding habits of reef dwellers, the predator-prey relationships of the reef food web and the relative importance of the reef and surrounding mud or sand habitats as food producers.

(3) Species diversity and standing stock biomass of soft substrate benthos near and away from reefs

Artificial reefs are typically located within vast stretches of sandy or muddy sea floor. Food habit studies have shown that many reef-associated fishes, although residing on reefs, obtain a considerable percentage of their diet by foraging on the surrounding soft bottom (Steimle and Ogden 1982). The fact that reef fish depend upon the surrounding environment for food means that reef size and spacing are critical factors influencing the abundance of fish that can inhabit a reef site. Therefore, understanding the carrying capacity of food resources of the surrounding sand environment is important in designing and building reefs.

(4) Baseline chemical contamination survey of selected species of reef fish and fouling fauna

The use of manmade materials, such as auto tires (not used anymore), plastic (not used), concrete debris and ships, to construct reefs opens the potential for introducing chemical compounds into the marine environment. There is a chance that substances leaching from reef structures may alter the physiology of fish, be toxic to larval forms of marine life or accumulate in the food chain and consequently, contaminate seafood species for human consumption. It is important to identify potential sources of toxicity or contamination so that steps can be taken to eliminate such substances from reef construction materials. Biological and ecological information collected by DEP during 1984-1999 includes:

(a) epifaunal (encrusted invertebrates) colonization or reef structures (Steimile and Figley 1996, Figley 2003);

(b) counts of adult fish on tire units;

(c) sandy bottom infauna on and off reef;

(d) young-of-year fish colonization of reef structures (Dixon and Figley 1994);

(e) potential bio-accumulation of toxins by mussels on reefs (Collins, et al 1997);

(f) food habits of reef fish and crustaceans (Steimle, Daetsch and Figley 2003);

(g) colonization of reefs by mobile invertebrates (Steimle and Figley 1996).

(h) movements of reef fish (Figley 2003);

6.5.2.2 Socio-Economic Assessments

The following monitoring programs will be conducted to assess the socio-economic aspects of New Jersey's reef network:

(1) Participation-effort-catch statistics of recreational angling, scuba diving and commercial pot fisheries on reefs.

Fisheries statistics are commonly collected by fisheries agencies to obtain the information needed to understand and manage fisheries. Fishery statistics are also helpful in assessing the effectiveness of reef building efforts. Since reef fisheries are a small component of the overall marine recreational and commercial fisheries, broad-based national or coastwide surveys are probably not intensive enough to accurately portray fishing activities on the reefs of a single state, thus creating the need to conduct additional, specific surveys focused on reef user groups.

(2) Economic value of recreational angling, scuba diving and commercial fisheries on reefs.

Artificial reefs are generally thought to be an economical way to improve fishing. Thus, economic analyses offer important means to assess the impact of reef building efforts by providing information on the value of reefs and the cost-effectiveness of building reefs and, if the numbers prove right, may help justify the expenditure of public funds to subsidize reef programs. The economic implications may also be used when selecting new reef sites, designing reefs and determining the magnitude of the reef construction effort at a site. Economic evaluations may also influence policies regarding reef resource allocations to various user groups.

(3) Annual costs of building New Jersey's reefs and the sources of funds.

The success of any reef building and management program is dependent upon its level of funding. The cost of doing business in the marine environment is very high. Most U.S. reef programs, including

New Jersey, are limited by funding and therefore, are often dependent upon materials donated from a variety of sources to support construction efforts. Likewise, reef monitoring is limited to the personnel, equipment and time available under a restricted budget. Since funding is the limiting factor to reef program effectiveness, the Reef Program should understand the economics of its activities – the amount spent on building and managing reefs, the sources of funds and the cost per unit of reef building materials. By combining this information with the value of reef resources, the cost-effectiveness of the program can be evaluated. This type of information is often valuable when seeking government funding.

(4) Opinions of reef users toward New Jersey's reef program.

Artificial reefs are built to serve the public. Reef users are the customers of New Jersey's Reef Program. And like any other business, the reef manager should pay attention to its customers. Social surveys are basically customer surveys that both profile reef users and assess public attitudes toward reef construction efforts. To provide the best possible product, it is necessary to know if the customer is satisfied and to identify needs that are not being satisfied. Social surveys also identify real and perceived problems, such as user conflicts, that may be addressed in reef siting, design and management policies. Surveys also serve as "trial balloons", which allow reef managers to gauge the public perception of potential management policies, such as licensing, conflict resolution and size and bag limits. By quantifying survey results, prioritized lists can be developed and attention can be focused on the most important issues. As with economic surveys, the results of social surveys can also be used to justify or promote public funding of reef programs.

Socio-economic monitoring efforts that have already been investigated include:

(1) Participation, effort and catch of recreational reef fisheries (Figley 1992a, Figley 1996a and Figley 2001);

(2) Fishing effort of commercial pot fisheries (Figley 1992b and Figley 1996b);

(3) Opinions of recreational anglers towards reef program (Figley and 1992);

(4) Expenditures of recreational reef anglers and divers (Brown and Figley 1992);

(5) Costs of constructing and managing reefs (Brown and Figley 1995).

7.0 REGULATORY AGENCIES

Many federal and state agencies are involved in developing, managing and regulating reefs and reef resources (ASMFC, GSMFC and PSMFC 1998). The role of each agency is briefly described below.

7.1 Federal Agencies

7.1.1 Department of Defense

7.1.1.1 U.S. Army Corps of Engineers

The ACOE is responsible for regulating activities within navigable waterways under sections 9 and 10 of the Rivers and Harbors Act of 1899. They also have permit authority under Section 404 of the Clean Water Act and Section 103 of the Marine Protection, Research and Sanctuaries Act. The agency is directly responsible for permitting artificial reef sites under the National Fishing Enhancement Act of 1984 (Section 203, 33CFR: 320-330). ACOE mandates conditions of the permits and approves the types of materials allowable for reef construction. ACOE also both generates and regulates the discharge of dredge materials, some of which (rock) may be used for reef construction.

7.1.2 Department of Homeland Security

7.1.2.1 U.S. Coast Guard

The USCG has authority to:

(1.) regulate aids to navigation (buoys) on reef sites;

(2.) establish navigation channels and navigational clearance (depth) requirements over reefs under the Ports and Waterway Safety Act;

(3.) enforce fishery laws;

(4.) monitor and enforce international environmental statutes, including inspecting vessels for potential pollutants before deployment on reefs.

7.1.3 Environmental Protection Agency

The EPA has authority to regulate ocean dumping and point source pollution under the Marine Protection Research and Sanctuaries Act. The agency is responsible for inspecting and approving vessels acquired from the Maritime Administration before deployment as reefs. The EPA developed the cleaning protocol for the preparation of obsolete military vehicles destined for artificial reefs. The EPA also develops standards for materials or chemicals that are introduced into natural waters.

7.1.4 Department of the Interior

7.1.4.1 U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (Service) requires the State to submit an Environmental Assessment for the creation of reefs built with funding from the Sportfish Restoration Program. The Service also participates in the development of FMPs through regional fisheries management councils.

7.1.5 Department of Commerce

7.1.5.1 National Marine Fisheries Service

NMFS is charged with the management of marine fisheries under the Magnuson Act as amended by the Sustainable Fisheries Act of 1996 and the coordination of interstate fisheries management under the Fish and Wildlife Act of 1956, the Inter-jurisdictional Fisheries Act of 1989 (P.L. 99-659) and the Atlantic Coastal Cooperative Fisheries Act (Section 804). NMFS works with the MAFMC and the ASMFC to develop FMPs for reef-associated species. NMFS is responsible for appraising and implementing all FMPs between 3 and 200 miles of the coast. NMFS also plays a lead role in the oversight and development of the nation's reef programs, including the review of permits and programs and the publication of the National Artificial Reef Plan.

7.1.5.2 National Ocean Survey

The National Ocean Survey (NOS) is responsible for plotting reef site locations on nautical charts and ascertaining the accuracy of the navigational coordinates of reef site boundaries, which the Division is required to provide.

7.1.6 Department of Transportation

7.1.6.1 U.S. Maritime Administration

The U.S. Maritime Administration has authority to transfer obsolete naval vessels to the state for reef deployment under the National Fishing Enhancement Act (P.L. 98-402: Section 207).

7.2 State Agencies

7.2.1 DEP Fish & Wildlife

F & W is responsible for managing New Jersey's marine fish and shellfish resources, the fisheries that depend upon them, and the environments which they inhabit. The Coastal Artificial Reef Planning Guide (ASMFC, GSMFC and PSMFC, 1998) recommends that "because of the potential long-term effects of altering the environment through artificial reef development, and the potential impacts of artificial reefs on finfish and shellfish stocks, eligibility to hold a permit to develop an artificial reef should be restricted to the appropriate state fishery management agency. The State's natural resource agencies hold the public trust in managing resources associated with artificial reefs and are the principal entities which can demonstrate long-term accountability for liability required in artificial reef permits". This is the typical formula followed in the majority of coastal states and is the policy followed by the State of New Jersey. As sole holder of reef permits in New Jersey, DEP is responsible for:

(1) obtaining reef permits;

(2) coordinating reef construction activities;

(3) assuming liability;

(4) conducting all of the monitoring studies required by permits;

(5) developing the New Jersey Reef Plan.

7.2.2 Land Use Regulation Program

DEP's Land Use Regulation Program is responsible for issuing environmental permits for reefs located within the State territorial sea (3 nautical miles). These permits include Waterfront Development Permits and Water Quality Certificates. Further, the land use Regulation Program is responsible for reviewing Federal Consistency determinations for artificial reefs proposed in Federal Waters.

7.3 Fisheries Management Councils

F & W is involved in three fisheries management councils, the New Jersey Marine Fishery Council, the Mid-Atlantic Fisheries Management Council (MAFMC) and the Atlantic States Marine Fisheries Commission (ASMFC).

7.3.1 New Jersey Marine Fisheries Council

The New Jersey Marine Fisheries Council consists of 11 members appointed by the Governor. The Council has the following duties and powers:

- Contribute to preparation and review of FMPs;
- Empowered to disapprove of rules and regulations proposed by the Department;
- Recommend marine fisheries rules and regulations to the DEP;
- Recommend governing of species-related citizen panels; and
- Analyze economic, social and ecological data relating to the operation of the marine fisheries program.

7.3.2 Mid-Atlantic Fisheries Management Council

The MAFMC is a federal council which includes representatives from the member states spanning the coast from New York to North Carolina. The Council is responsible for developing FMPs, including those for reef species.

The MAFMC is further responsible for the granting of SMZs on artificial reefs in Federal waters. SMZs are areas that have special restrictions on fishing gear. SMZ proposals must be submitted to the MAFMC for consideration by the reef permit holder.

7.3.3 Atlantic States Marine Fisheries Commission

The ASMFC is an interstate commission composed of representatives from the coastal states from Maine to Florida. It is primarily responsible for managing species which inhabit the Atlantic Coast territorial sea.

The ASMFC also has an Artificial Reef Technical Committee. This committee is composed of representatives from member states as well as federal environmental agencies. The Committee meets semi-annually and its goals are to exchange information, resolve coastwide issues, coordinate research and construction efforts and standardize procedures and criteria. DEP sends a representative of the Reef Program to each committee meeting as a voting member.

APPENDIX A

Policy Directive 2003 -02

Setting artificial reef pilot and standards revision and conducting a study.

Policy Directive 2003-02
Setting Artificial Reef Pilot and Standards Revision and Conducting a Study

Artificial reefs, if properly designed of appropriate materials, can provide significant benefits to the marine environment and to commercial and recreational users of our ocean resources. Artificial reefs can improve marine habitat and provide structure for benthic marine organisms while enhancing recreational and commercial fishing and diving opportunities.

Over the past several years, there has been controversy surrounding appropriate materials for use in an artificial reef program, and concern that the quest for artificial reefs not transform our ocean waters into a dumping ground for waste material. Where materials proposed for use in artificial reefs are inappropriate or present the potential for adverse environmental impacts, New Jersey's policy is that the interest in accelerating artificial reef development must yield to our paramount commitment to the protection of ocean resources.

Balancing the current record against ongoing public concern about these conclusions, I authorize and direct as follows.

1. The Office of Natural and Historic Resources (NHR) shall proceed to arrange the placement of a total of up to 250 subway cars, distributed among five currently designated reef sites at Garden State North, Atlantic City, Cape May, Shark River and Deep Water (off Ocean City).

2. DEP shall establish a program, in of monitoring these sites for eight years; to ascertain any impacts and to ascertain the structural integrity and durability of the material and its efficacy in providing habitat in each marine environment. The program shall conclude in a report to the Commissioner subject to public notice and comment. To develop the report, DEP shall initiate a balanced and independent scientific and technical reef advisory committee (TRAC), made of regional reef ecologists and scientists from relevant interests, including the National Marine Fisheries Service, EPA, other States agencies and NJDEP Fish & Wildlife, fisheries and marine ecosystem experts, and academia. The TRAC will develop and follow monitoring requirements and plans for an eight-y6ar study to include, but not be limited to:

- monitoring potential asbestos impacts to sediments and biota, with

three offsite controls. Samples will be collected and tested every two years over an eight-year period.

- monitoring of durability and stability of subway cars

- conducting a comparative fisheries productivity and diversity assessment to other reef materials; and

- recommending procedures for contingencies should adverse effects from the asbestos materials be found

At the end of the eight-year study, the TRAC will review the data and make a determination on whether the subway cars meet the standard set forth in paragraph 4 and make further recommendations for artificial reef standards, if needed. The TRAC shall submit progress reports annually.

3. A moratorium on the placement of certain artificial reef materials that do not meet the standards in paragraph 4, including additional subway cars, shall be established until the monitoring and reporting program in paragraph two is complete.

4. The State artificial reef plan, proposed regulations, and other relevant documents shall be immediately revised to include requirements that artificial reef materials be limited to those materials that consist entirely of thick dense materials that build stable and durable reefs for decades and the Plan should be put out for public comment- Any new artificial reef materials, with the exception of the proposed study on subway cars, must meet a standard of "retaining a minimum of 90 percent of original structural integrity for 30 or more years." Currently, there is no federal standard, but the National Plan states that artificial reef materials must be resistant to deterioration and breakup.

5. Prior to publication of the draft artificial reef plan now under development, DEP shall conform the draft plan to this Directive. Specifically, DEP shall include in the Plan a requirement that "Materials of Opportunity" meet the standard of "retaining a minimum of 90 percent of original structural integrity for 30 or more years," in addition to all other standards. Similar conforming changes shall be proposed by the State for the applicable permits governing the artificial reef sites and rules on coastal zone management and other enforceable policies or relevant documents.

6. In addition to the above described limitations, any material proposed for artificial reefs in the future shall be carefully evaluated to demonstrate that the material is pollution free.

7. Based on historic placement and evaluation the following materials are deemed to meet the standard in paragraph 4: ships/barges; dredged rock and rock; cast concrete forms, pipe, slabs, and blocks; structural steel exceeding 0.25 inches thick; obsolete military vehicles; and manufactured reef habitats especially designed and made of concrete or steel. Relevant DEP plans, rules, regulations, and other relevant documents shall deem these materials to meet the standard.

This directive creates no enforceable rights, legal or equitable, for any person. Nothing in. this directive limits the discretion of the Commissioner to make further policy changes in response to public comment and additional data and analysis.

Date7/ Bradley/M. Campbell
Commissioner

APPENDIX B

Charts of New Jersey's 14 artificial reef sites.

Sandy Hook Reef

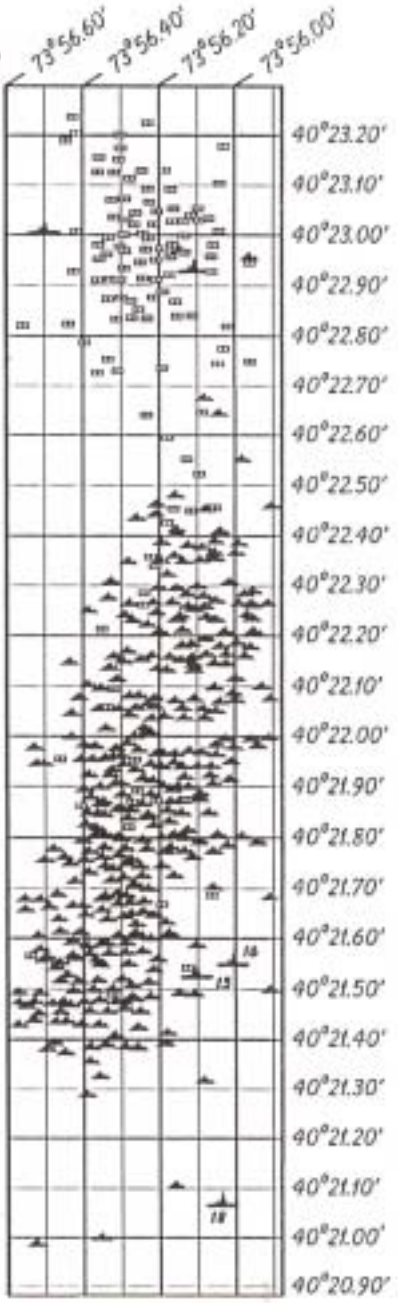
DGPS

From →	Sandy Hook Inlet	Shark River Inlet	Manasquan Inlet
Compass bearing	192°	27°	24°
Distance, (n.m.)	5.2	11.3	17.9

Distance offshore:----- 1.4 n.m.
Reef area:----------- 1.4 sq. mi.
Depth range:---------- 40-60 ft.

Key
Vessels
Rock
Concrete
Tanks

0 1/4 1/2
Nautical Miles



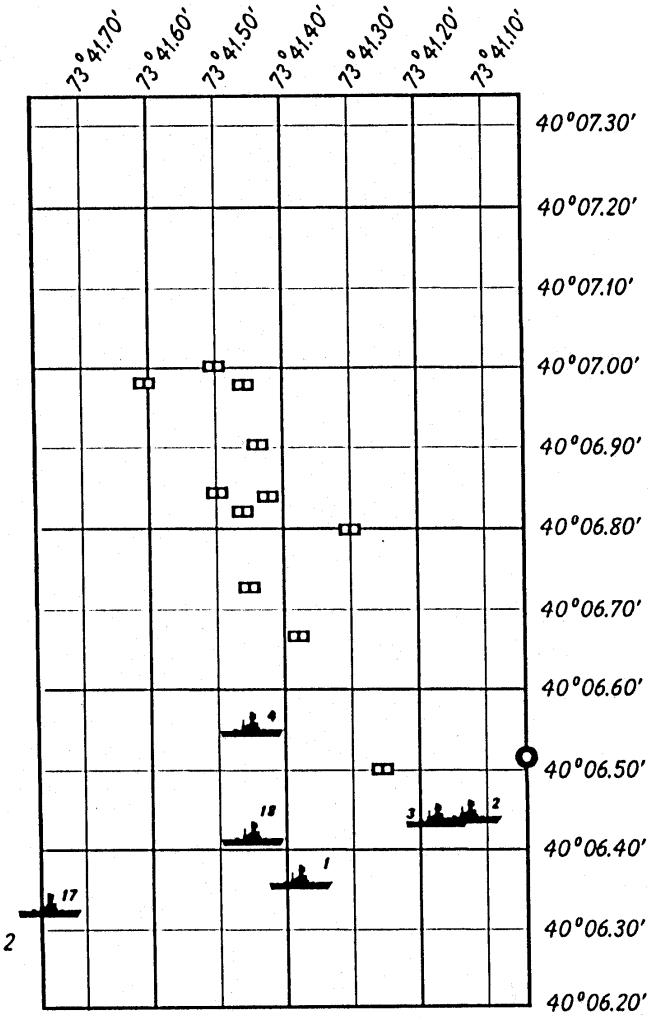
Shark River Reef

DGPS

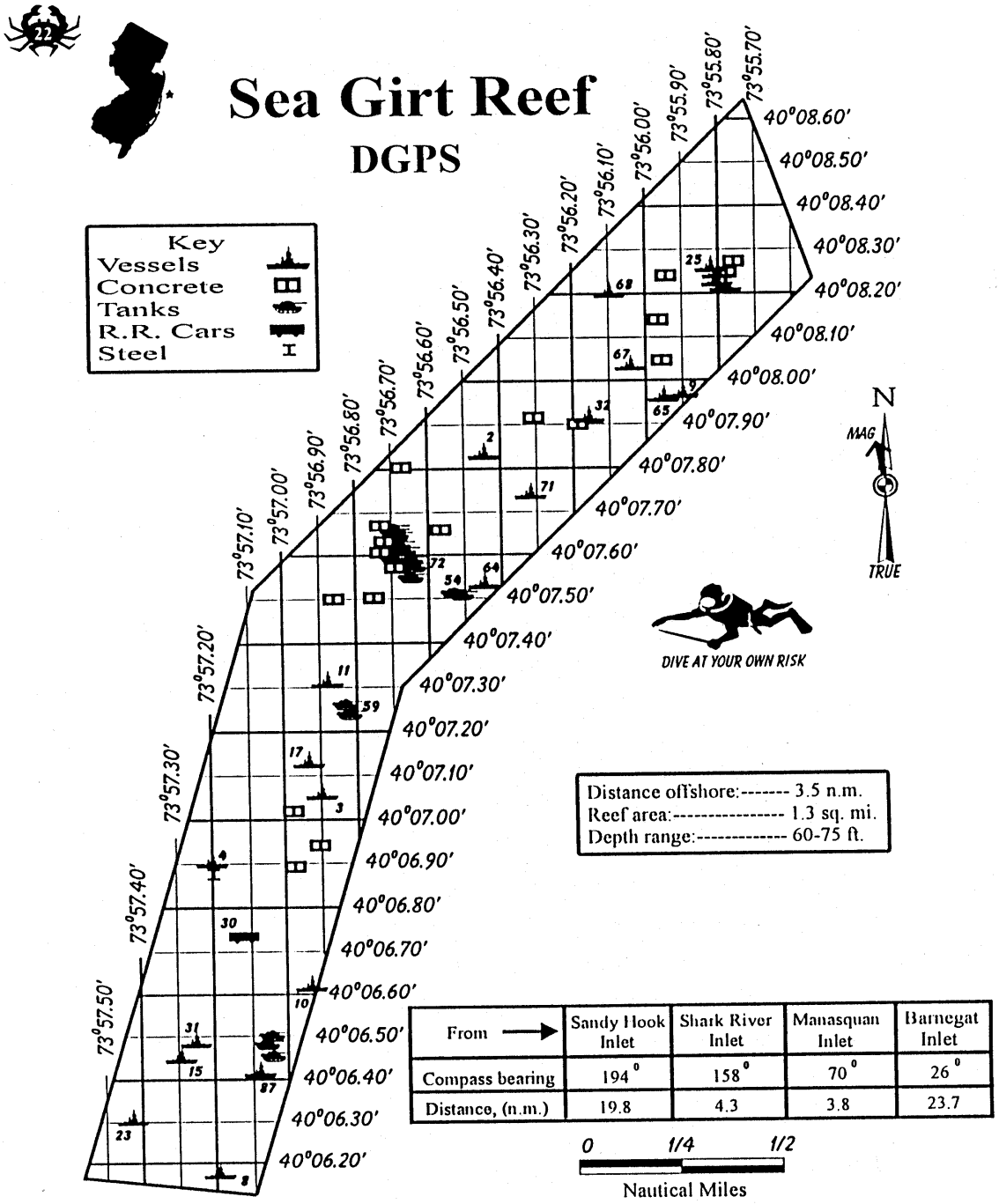
From →	Sandy Hook Inlet	Shark River Inlet	Manasquan Inlet
Compass bearing	166°	119°	100°
Distance, (n.m.)	22.3	14.8	15.6

Distance offshore:----- 14.8 n.m.
Reef area:---------- 0.72 sq. Mi.
Depth range:---------- 119 -128 ft.

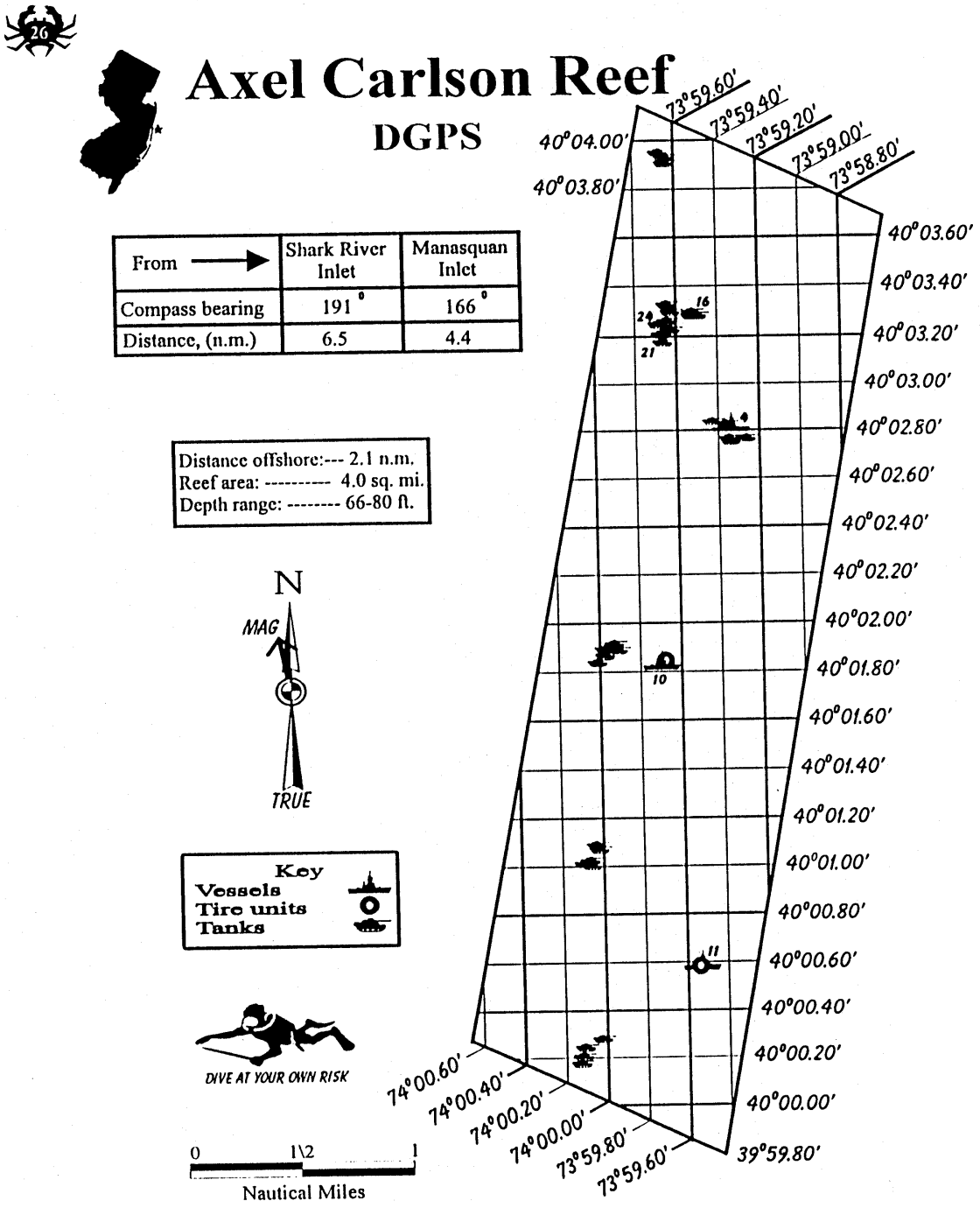
Key
Vessels
Tire units
Concrete



0 1/4 1/2
Nautical Miles



From →	Sandy Hook Inlet	Shark River Inlet	Manasquan Inlet	Barnegat Inlet
Compass bearing	194°	158°	70°	26°
Distance, (n.m.)	19.8	4.3	3.8	23.7


26
Axel Carlson Reef
DGPS
From
Shark River Inlet
Manasquan Inlet
Compass bearing
191°
166°
Distance, (n.m.)
6.5
4.4
Distance offshore:--- 2.1 n.m.
Reef area: ---------- 4.0 sq. mi.
Depth range: -------- 66-80 ft.
N
MAG
TRUE
Key
Vessels
Tire units
Tanks
DIVE AT YOUR OWN RISK
0
1\2
1
Nautical Miles
73°59.60'
73°59.40'
73°59.20'
73°59.00'
73°58.80'
40°04.00'
40°03.80'
40°03.60'
40°03.40'
40°03.20'
40°03.00'
40°02.80'
40°02.60'
40°02.40'
40°02.20'
40°02.00'
40°01.80'
40°01.60'
40°01.40'
40°01.20'
40°01.00'
40°00.80'
40°00.60'
40°00.40'
40°00.20'
40°00.00'
39°59.80'
74°00.60'
74°00.40'
74°00.20'
74°00.00'
73°59.80'
73°59.60'
16
24
21
4
10
11

94

Barnegat Light Reef

DGPS

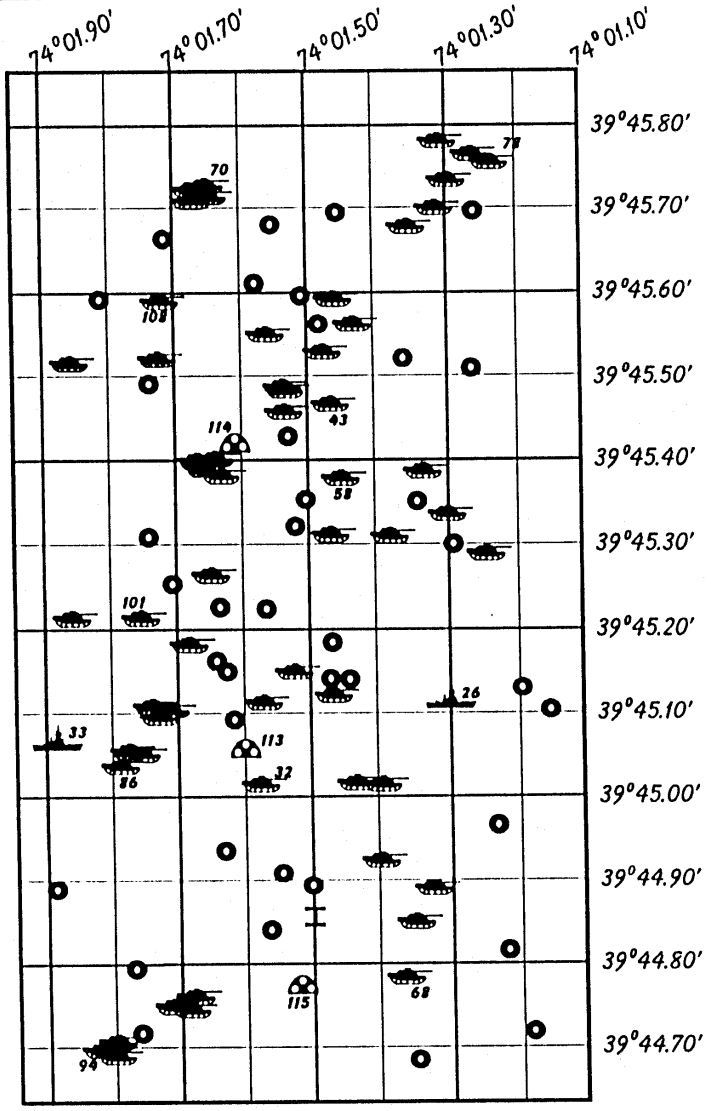
From →	Manasquan Inlet	Barnegat Inlet	Little Egg Inlet
Compass bearing	194°	103°	46°
Distance, (n.m.)	20.5	3.1	21.0

Distance offshore:--- 3.0 n.m.
Reef area: ---------- .85 sq. mi.
Depth range: -------- 46-58 ft.

DIVE AT YOUR OWN RISK

Key
Vessels
Tire Units
Tanks
Reef Balls
Steel

0 1/4
Nautical Miles

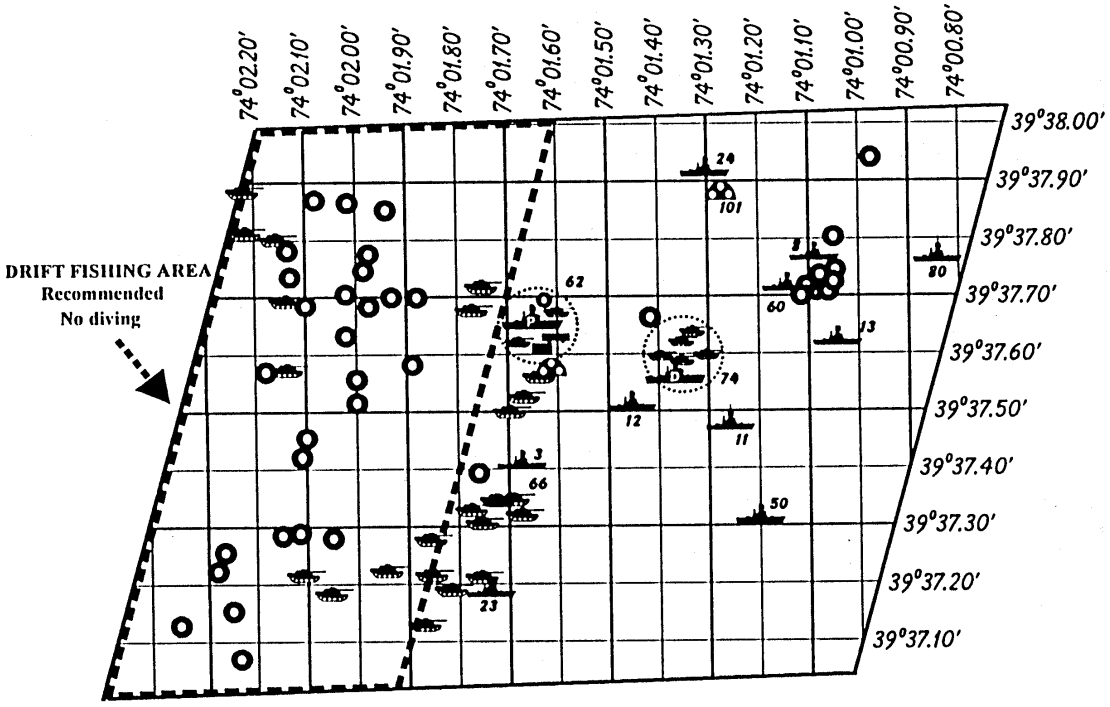


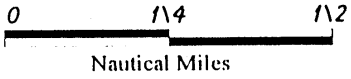
Garden State North Reef

DGPS

Distance offshore--- 6.5 n.m.
Reef area----------1.1 sq. mi.
Depth range----------66-83 ft.

From →	Barnegat Inlet	Little Egg Inlet
Compass bearing	172°	60°
Distance, (n.m.)	7.7	14.4





Key
Vessels
Tire units
Concrete
Tanks
R.R.cars
Reef balls

Garden State South Reef

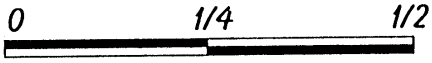
DGPS

From →	Barnegat Inlet	Little Egg Inlet	Absecon Inlet
Compass bearing	198 °	64 °	58 °
Distance, (n.m.)	11.1	9.1	18.4

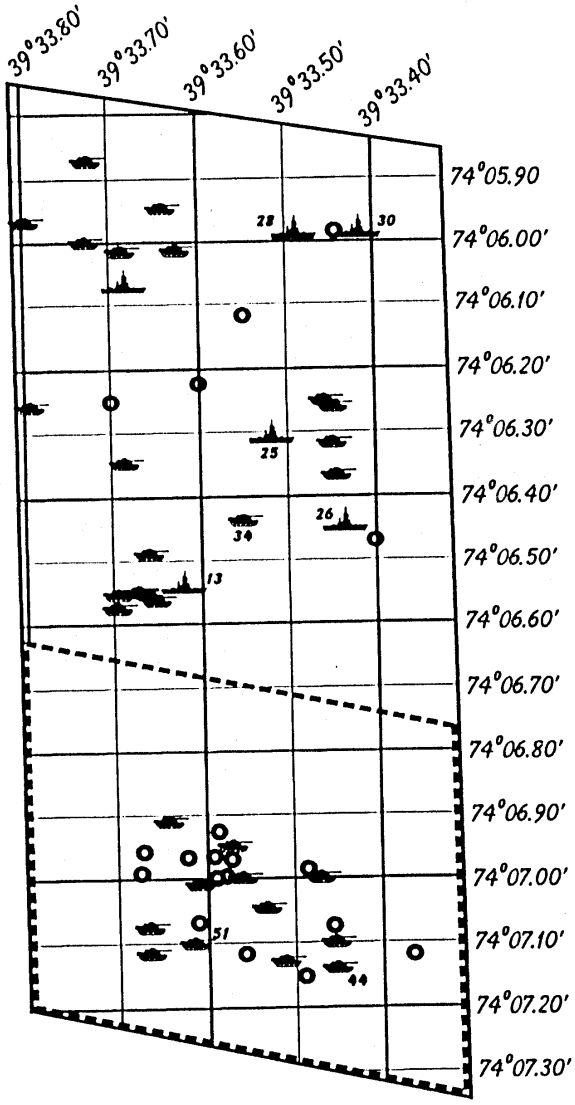
Distance offshore:--- 5.1 n.m.
Reef area: ---------- 0.6 sq. Mi.
Depth range: -------- 57-63 ft.

DIVE AT YOUR OWN RISK

Key
Vessels
Tire units
Tanks



Nautical Miles



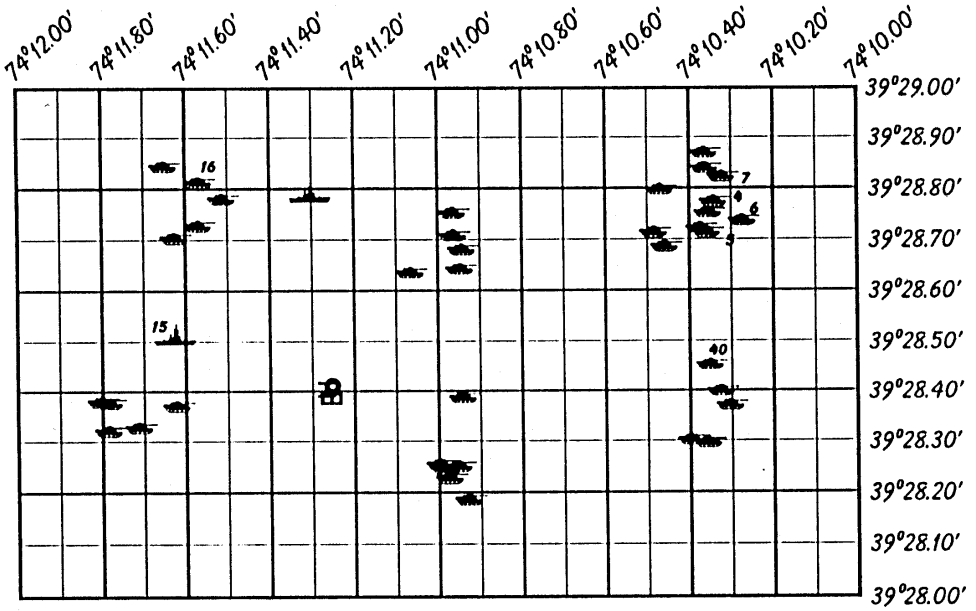
38

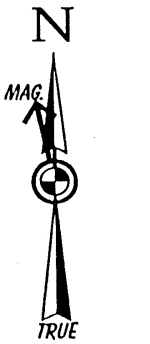
Little Egg Reef

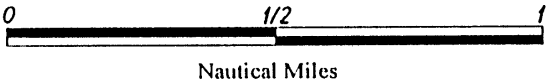
DGPS

Little Egg Inlet	← From →	Absecon Inlet
93 °	Compass bearing	53 °
5.05	Distance, (n.m.)	12.37

Distance offshore:----------3.8 n.m.
Reef area: ----------1.5 sq. Mi.
Depth range: ---------- 48 - 60 ft.

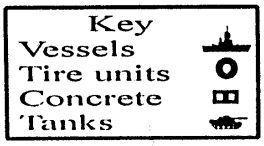






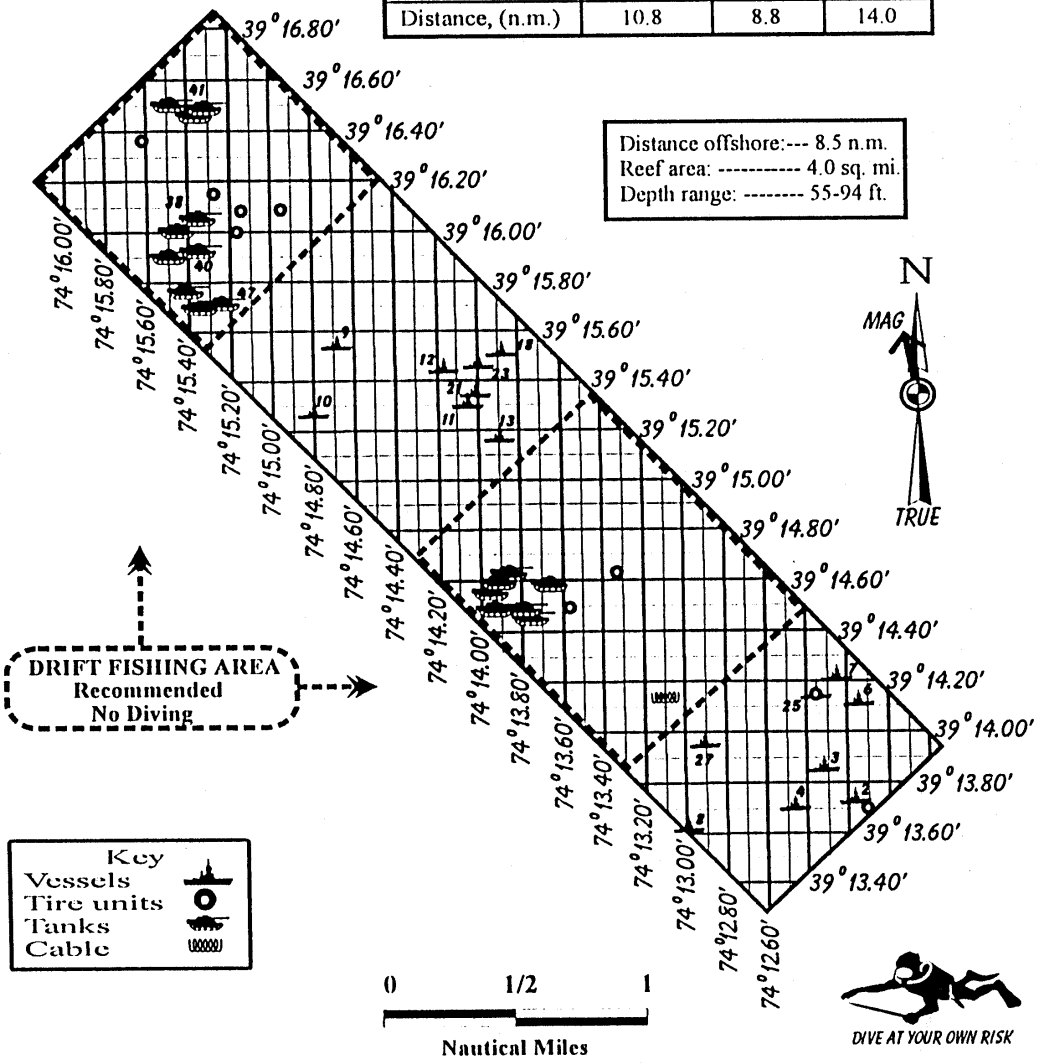
Nautical Miles

DIVE AT YOUR OWN RISK



Atlantic City Reef
DGPS

From →	Little Egg Inlet	Absecon Inlet	Great Egg Inlet
Compass bearing	189 °	142 °	106 °
Distance, (n.m.)	10.8	8.8	14.0

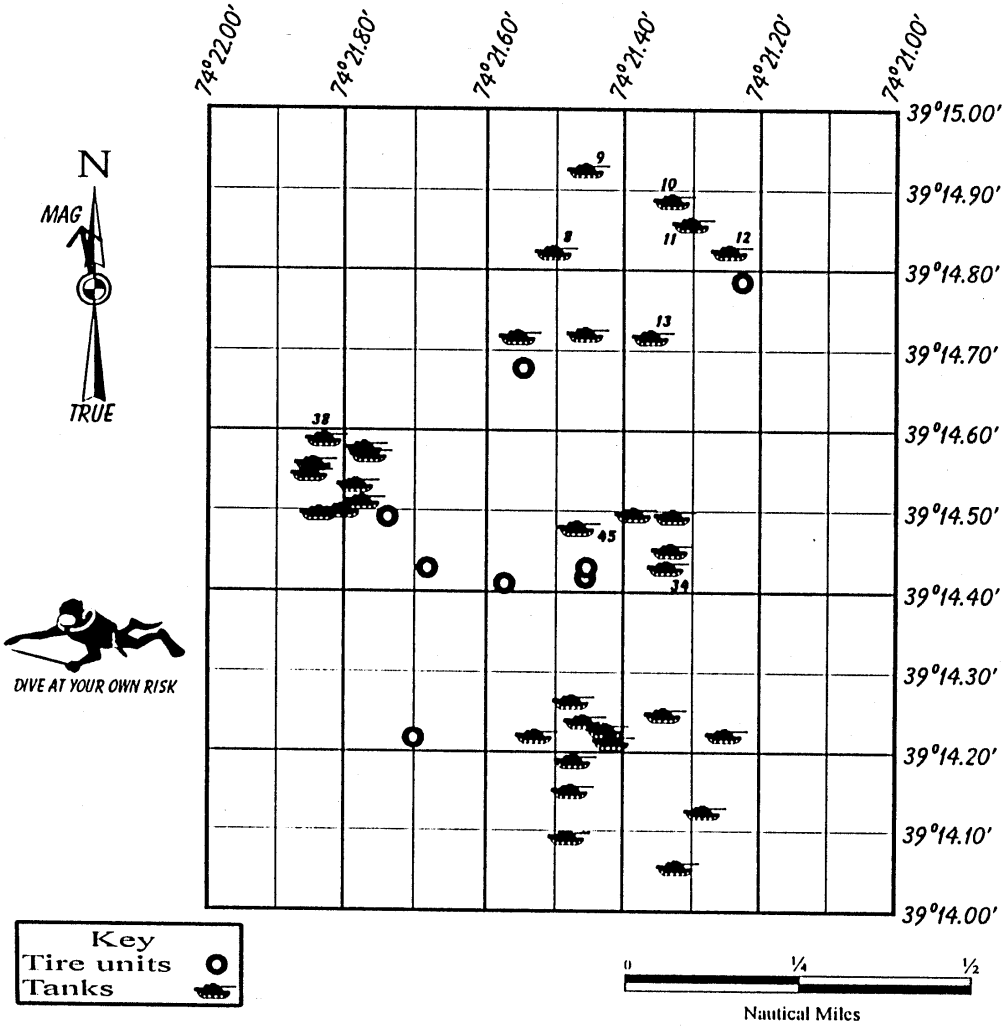


Great Egg Reef

DGPS

Distance offshore:--- 7.0 n.m.
Reef area: ---------- 1.0 sq. mi.
Depth range: -------- 47-70 ft.

From →	Great Egg Inlet	Absecon Inlet	Corson's Inlet
Compass bearing	110°	165°	82°
Distance, (n.m.)	9.2	8.0	13.4

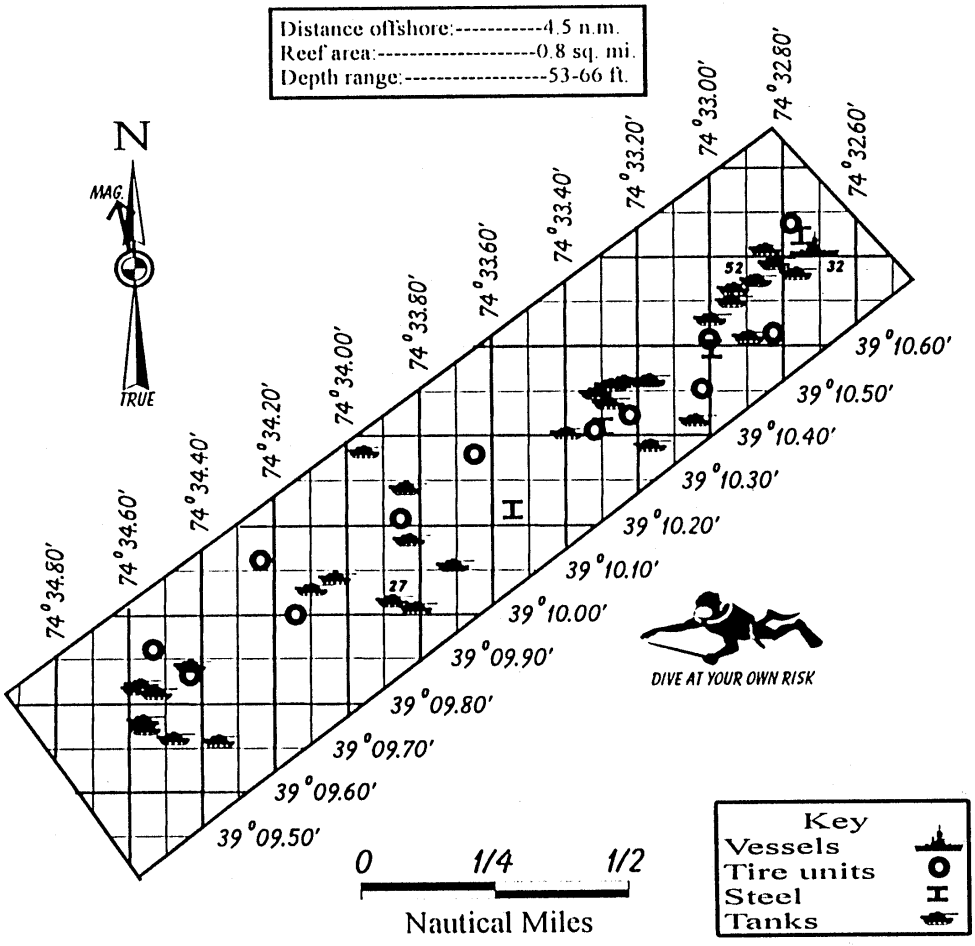


Ocean City Reef

DGPS

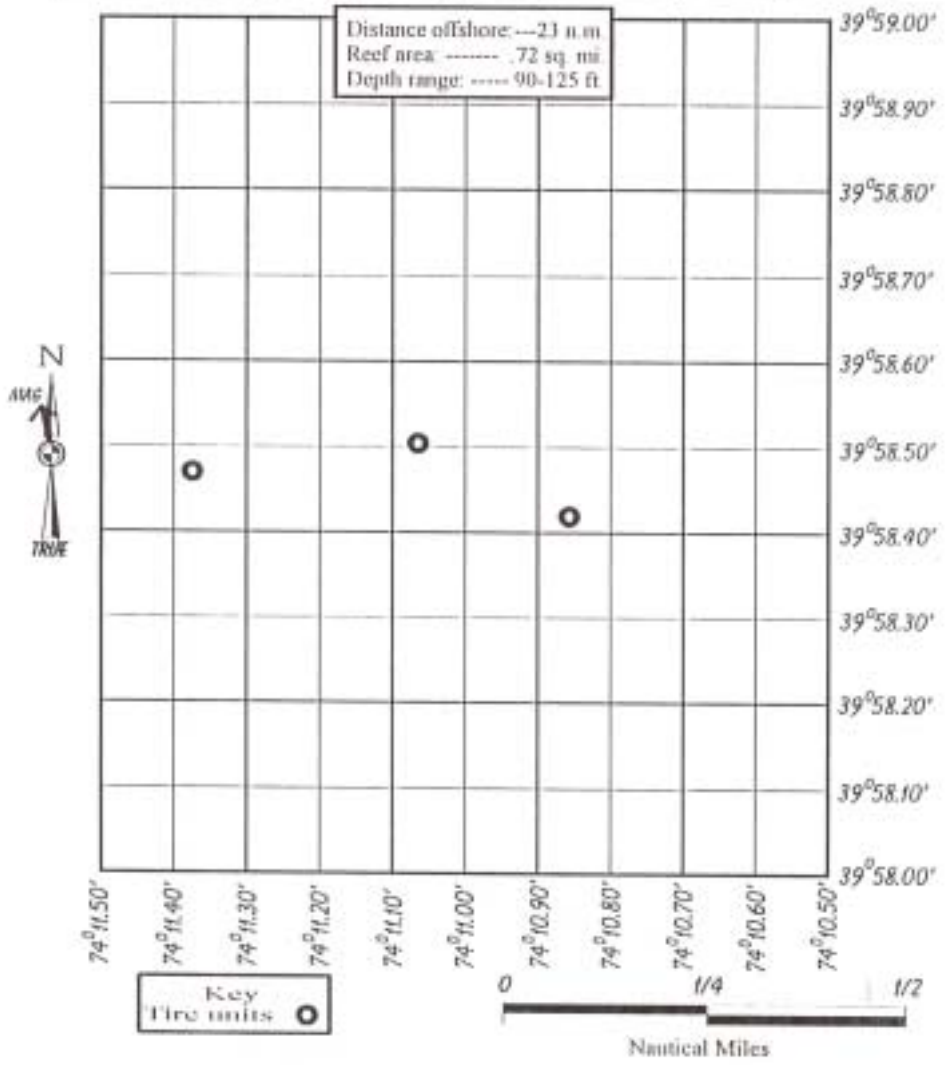
From →	Great Egg Inlet	Corson's Inlet	Townsends Inlet
Compass bearing	215°	131°	64°
Distance, (n.m.)	7.4	4.3	7.4

Distance offshore:----------4.5 n.m.
Reef area:----------0.8 sq. mi.
Depth range:----------53-66 ft.



Deepwater Reef
DGPS

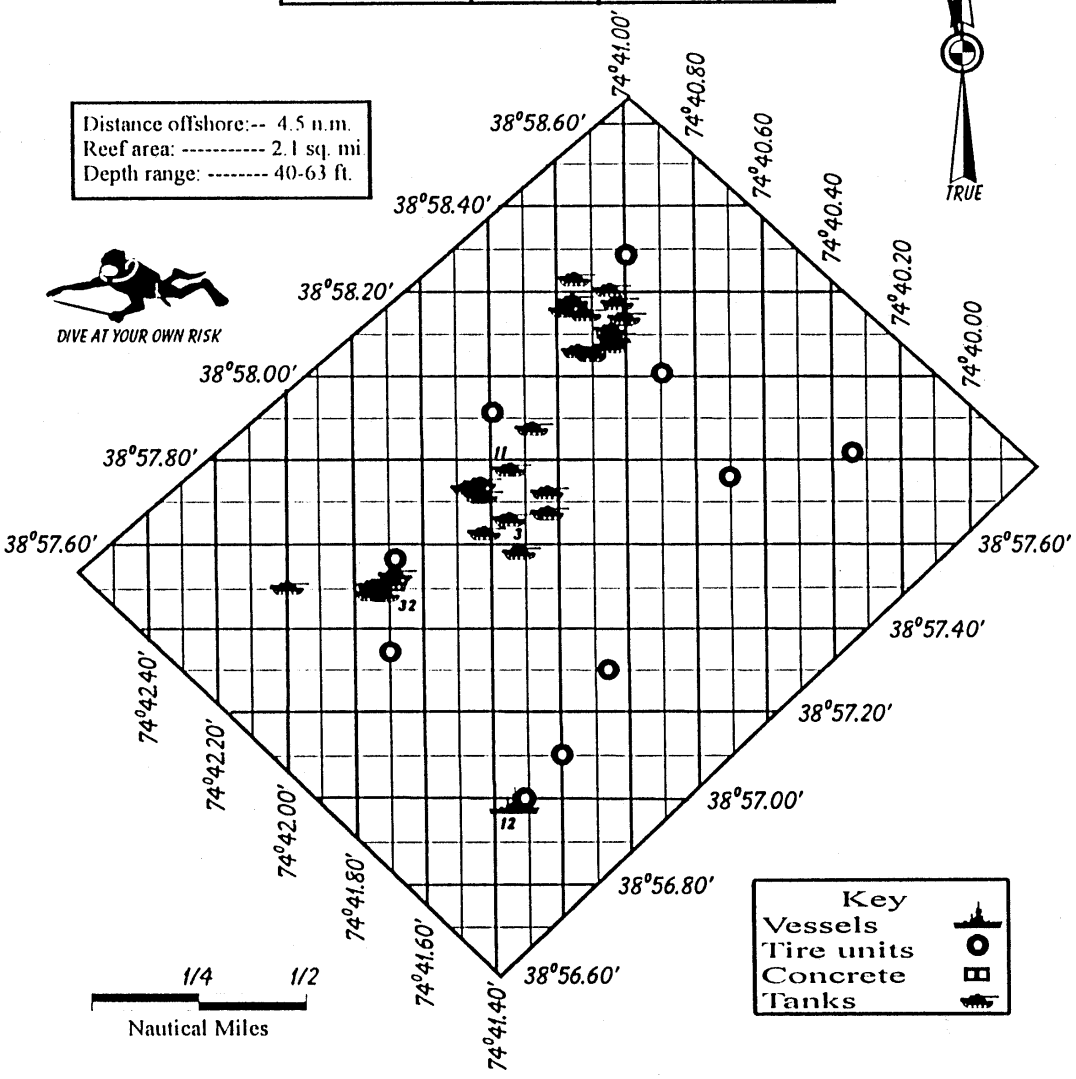
From →	Little Egg	Absecon Inlet	Great Egg	Townsends Inlet	Hereford Inlet	Cape May Inlet
Compass bearing	183°	168°	153°	122°	103°	99°
Distance, (n.m.)	28.3	25.0	23.6	24.4	27.4	31.5

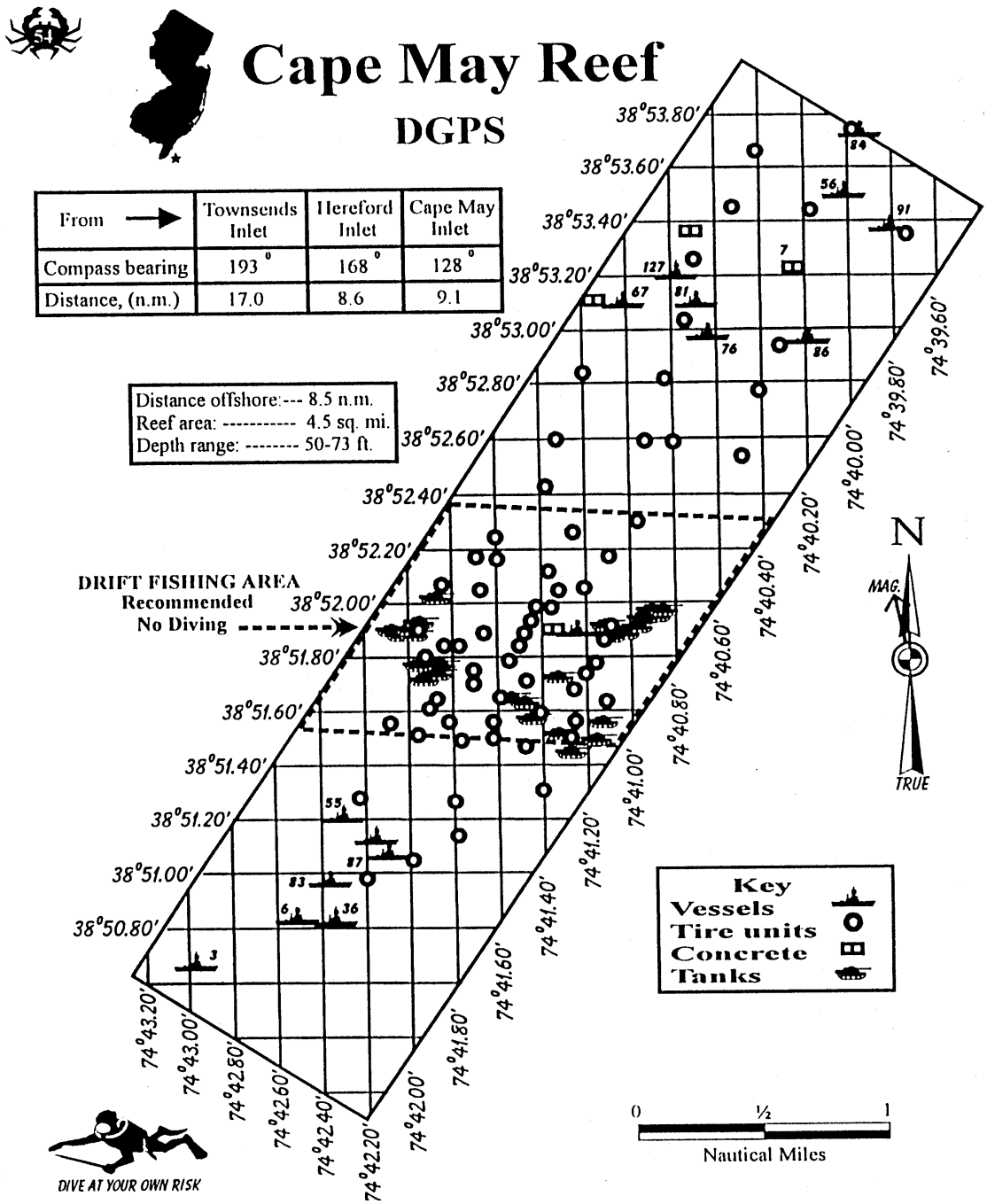


Wildwood Reef

DGPS

From →	Townsends Inlet	Hereford Inlet	Cape May Inlet
Compass bearing	190 °	135 °	88 °
Distance, (n.m.)	9.2	4.5	8.3




54
Cape May Reef
DGPS
From
Townsends Inlet
Hereford Inlet
Cape May Inlet
Compass bearing
193°
168°
128°
Distance, (n.m.)
17.0
8.6
9.1
Distance offshore:--- 8.5 n.m.
Reef area: ---------- 4.5 sq. mi.
Depth range: -------- 50-73 ft.
DRIFT FISHING AREA
Recommended
No Diving
38°53.80'
38°53.60'
38°53.40'
38°53.20'
38°53.00'
38°52.80'
38°52.60'
38°52.40'
38°52.20'
38°52.00'
38°51.80'
38°51.60'
38°51.40'
38°51.20'
38°51.00'
38°50.80'
74°43.20'
74°43.00'
74°42.80'
74°42.60'
74°42.40'
74°42.20'
74°42.00'
74°41.80'
74°41.60'
74°41.40'
74°41.20'
74°41.00'
74°40.80'
74°40.60'
74°40.40'
74°40.20'
74°40.00'
74°39.80'
74°39.60'
N
MAG.
TRUE
Key
Vessels
Tire units
Concrete
Tanks
0
½
1
Nautical Miles
DIVE AT YOUR OWN RISK

REFERENCES CITED

American Sportfishing Association. 1997. The 1996 economic impact of sport fishing in New Jersey. U.S. Fish and Wildlife Service Grant No. 14-48-0009-1237. 10 pp.

ASMFC, GSMFC and PSMFC. 1998. Coastal Artificial Reef Planning Guide. FWS Grant GS-96 and AP-98-501. 45 pp.

Bockstael, N., A. Graefe and I. Strand. 1985. Economic analysis of artificial reefs: an assessment of issues and methods. Artificial Reef Development Center. Technical Report No. 5. 93 pp.

Bohnsack, J.A. and D.L. Sutherland. 1985. Artificial reef research: a review with recommendations for future priorities. Bulletin of Marine Science 37(1):11-39.

Brown, B. and B. Figley. 1992. An economic analysis of New Jersey's wreck and artificial reef fisheries. N.J. Division of Fish, Game and Wildlife. Federal Aid to Fisheries Project F-15-R-23. 11 pp.

Brown, B. and B. Figley. 1995. The economics of the production and maintenance of New Jersey's artificial reefs. N.J. Division of Fish, Game and Wildlife. Federal Aid to Fisheries Project F-15-R-36. 23 pp.

Buchanan, C.C. 1972. A comparison of sport fishing statistics from man-made and natural habitats in the New York Bight. Proceedings of Sportfishing Seminar. Jekyll Island, GA. Seminar Series No. 1. 41 pp.

Buller, R.J. and H.S. Spear. 1950. A survey of the sports fishery of the Middle Atlantic Bight in 1948. U.S. Dept. of Interior. Special Scientific Report. Fisheries No. 7.

Carlson, J., B. Preim and B. Figley. 2003. The Shipwrecks of New Jersey's Reefs. NJ Division of Fish and Wildlife. 160 pp.

DEP. 1990. Rules on Coastal Zone Management. Division of Coastal Resources. Trenton, NJ. 248 pp.

Figley. B. 1981. A brief history of saltwater fishing in New Jersey. N.J. Division of Fish, Game and Wildlife. Technical Report FW-54-P. 38 pp.

Figley, B., B. Preim and S. Perrone. 1989. A guide to Fishing and Diving New Jersey's Artificial Reefs. NJ Div. Fish and Wildlife. Informational Series 89-1. 80 pp.

Figley, B. 1992. Survey of New Jersey's recreational wreck/artificial reef fisheries, 1991. N.J. Division of Fish, Game and Wildlife. Federal Aid to Fisheries Project F-15-R-33. 70 pp.

Figley, B. 1992b. Use of artificial reefs by commercial fish and lobster potters. N.J. Division of Fish, Game and Wildlife. 9 pp.

Figley, B. 1994. A Comparison of fish and invertebrate use of experimental artificial reef habitats in three marine habitats. N.J. Division of Fish, Game and Wildlife. Federal Aid to Fisheries. F-15-R-36. 24 pp.

Figley, B. 1996a. Survey of New Jersey's recreational wreck/artificial reef fisheries, 1995. N.J. Division of Fish, Game and Wildlife. Federal Aid to Fisheries Project F-15-R-37. 58 pp.

Figley, B. 1996b. Use of artificial reefs by commercial fish and lobster potters, 1991. N.J. Division of Fish, Game and Wildlife. 8 pp.

Figley, B. 1999. Summary of reef materials deployed through 1998. N.J. Division of Fish, Game and Wildlife. Federal Aid Fisheries Project F-15-R-39.

Figley, B. 2001. Survey of New Jersey's Recreational Wreck/Reef fisheries, 2000. N.J. Division of Fish and Wildlife. Federal Aid to Fisheries Project F-15-R-41. 59 pp.

Figley, B. and S. Marin. 1998. Opinions of fishermen toward New Jersey's reef program, 1997. N.J. Division of Fish, Game and Wildlife. Federal Aid to Fisheries Project No. F-15-R-38. 21pp.

Figley, B. 2003. Marine life colonization of experimental reef habitat in temperate ocean waters of New Jersey. NJ Division of Fish and

Wildlife. Federal Aid to Sportfish Restoration Proj. F-69-D-11. 80 pp.

Figley, B. 2003. Micro-movements of black sea bass on Atlantic City Reef Site. NJ Div. Fish and Wildlife. Federal Aid to Fisheries Project. 17 pp.

Freeman, B.L. and L.A. Walford. 1974. Angler's Guide to the United States Atlantic Coast. U.S. Government Printing Office. Washington, D.C. Stock No. 0320-00072.

Hamer, P.E. and R.R. Younger. 1952. Inventory of New Jersey salt water sport fishery. N.J. Dept of Conservation and Economic Development. Federal Aid Project. F-2-R-1. 47 pp.

Hueckel, G.J. and R. Buckley. 1982. Site selection procedures for marine habitat enhancement in Puget Sound, Washington. Washington Dept of Fisheries. Technical Report. 67: 1-82.

Huppert, D.D. 1983. NMFS guidelines on economic valuation of marine recreational fishing. NOAA Technical Memorandum NOSS-TM-NMFS-SWFC-32. Dept of Commerce. Washington, D.C. 35 pp.

Jenson, R.E. 1983. Atlantic Coast Hindcast, Shallow-Water Significant Wave Information. U.S. Army Corps of Engineers. Vicksburg, MS. WIS Report 9.

Lindberg, W.J. 1996. Fundamental design parameters for artificial reefs: interaction of patch reef spacing and design. Florida Dept of Environmental Protection. Grant Number C-6729. 60 pp.

Lindquist, D.G. and L.J. Pietra-fesa. 1989. Current vortices and fish aggregations: the current field and associated fishes around a tugboat wreck on Onslow Bay, North Carolina. Bull. Marine Science 44(2): 533-544.

Long, D. and W. Figley. 1982. New Jersey's recreational and commercial ocean fishing grounds. N.J. Division of Fish, Game and Wildlife. Technical Series 82-1. 38pp.

Lukens, R.R. 1997. Guidelines for marine artificial reef materials. Gulf States Marine Fisheries Commission. Number 38. 118 pp.

Lukens, R.R., J.D. Cirino, J.A. Ballard and G. Geddes. 1989. Two methods of monitoring and assessment of artificial reef materials. Gulf States Marine Fisheries Commission. Special Report No. 2-WB. Ocean Springs, MS.

Merriner, J.W. 1981. Rapporteur's comments, third technical section. In: D.Y. Aska (ed.), Artificial reefs: conference proceedings, Florida Sea Grant College Report. No. 41: 182-183.

McCay, B.J., G. Grant and A. Adelaja. 1995. The status and condition of New Jersey's marine fisheries and seafood industries. The Ecopolicy Center. Cook College. New Brunswick, N.J. 160 pp.

Myatt, D.O. and R.B. Ditton. 1986. Exclusionary mapping for artificial reef site selection to maximize recreational fishing benefits in the Gulf of Mexico. Artificial Reef Development Center. 157 pp.

Odum, E.P. 1953. Fundamentals of ecology. W.B. Saunders Co. Philadelphia, PA. 546 pp.

Preim, B., J. Carlson and B. Figley. 2000. A guide to fishing and diving New Jersey reefs. Artificial Reef Association. Oceanville, NJ. 64 pp.

Rassan, G.N. ed. 2000. Celebrating 50 years of the Sportfish Restoration Program. American Fisheries Society. Special supplement to Fisheries. 125 (7): 84 pp.

Scott, L.C. and F.S. Kelley. 1998. An evaluation and comparison of the benthic community assemblages with potential offshore sand borrow site(s) for Barnegat Inlet to Little Egg Inlet (Long Beach Island), New Jersey-feasibility study. Prepared for US Army Crops Engineers, Philadelphia District (100 Penn Square East, Philadelphia, PA 19107) by Versar, Inc. (9200 Rumsey Road, Columbia MD 21045) under direction of William Burton, Contract # DACW61-95-D-0011.5 sections, variously paginated.

Seaman, W. Jr., G.A. Antonini, S.A. Bortone, J.G. Halusky, S.M. Holland, W.J. Lindberg, J. Loftin, J.W. Millon, K.M. Portier, Y.P Sheng, A. Szmant and L. Zobler. 1992. Environmental and fishery performance of Florida artificial reef habitats: Guidelines for technical evaluation of sites developed with state construction assistance. Florida Sea Grant College Program Project #R/FDNR-4. 271 pp.

Seaman, W., Jr. ed. 2000. Artificial Reef Evaluation. CRC Press. Boca Raton, FL. 246 pp.

Spinello, J. 1998. NJDEP Strategic Plan: 1998-2001. NJDEP, Trenton, NJ. 36 pp.

Steimle, F.W. and L. Ogden. 1982. Food of fish collected on artificial reefs in the New York Bight and off Charleston, SC. Marine Fisheries Review 44 (6-7): 49-52.

Steimle, F.W. 1985. Biomass and estimated productivity of the benthic macrofauna in the New York Bight: a stressed coastal area. Estuar., Coast.Shelf Sci. 21:539-554.

Steimle, F.W. 1990. Benthic macrofauna and habitat monitoring on the Coastal shelf of the northeastern United States I. Biomass. NOAA Tech. Report NMFS 86. 28 pp.

Steimle, F., K. Foster, R. Kropp, and B. Conlin. 2002 Benthic macrofaunal productivity enhancement by an artificial reef in Delaware Bay, USA. ICES J. Mar. Sci. 59:S100-S015.

Steimle, F.W., Jr. and B. Figley. 1996a. 1994 epifauna on tire units from the Garden State North and Garden State South artificial reefs off Long Beach Island, NJ. Northeast Fisheries Science Center Reference Document 96-09. 17 pp.

Steimle, F.W., Jr. and B. Figley. 1996. The importance of artificial reef epifauna to black sea bass diets in the Middle Atlantic Bight. North American Journal of Fisheries Management. 16: 433-439.

Steimle, F.W. and C, Zetlin. 2000. Reef habitats in the Middle Atlantic Bight: abundance, distribution, associated biological communities and fishery resource use. Marine Fisheries Review. 62(2): 24-41.

Steimle, F.W., J. Daetsch and B. Figley. 2003. Food habits investigation of American Lobster, Homarus Americanus on New Jersey ocean reef sites. NJ Div. Fish and Wildlife. Federal Aid to Fisheries Project. In press.

Stone, R.B. 1985. National Artificial Reef Plan. NOAA Technical Memo. NMFS Of-6. 39 pp. plus Appendix.

Turner, C.H., E.E. Ebert and R.R. Given. 1969. Man-made reef ecology. Calif. Dept of Fish and Game. Fish Bulletin 146. 221 pp.

Vik, S.F., ed. 1982. Japanese artificial reef technology. Aquabio, Inc. 2957 Sunset Blvd., Belair Bluffs, Fl. Tech. Rep. 604. 308 pp.

Wendt, P.H., D.M. Knott, and R. F. VanDolah. 1989. Community structure of sessile biota on five artificial reefs of different ages. Bull. Marine Science. 44 (3): 1106-1122.

Younger, R.R. and P.E. Hamer. 1954. New Jersey's salt water sport fishery inventory, 1953. Trans. 19th North American Wildlife Conference. 423-429.

GLOSSARY

ACOE – Army Corp of Engineers

Angler – a fisherman using hook and line gear to catch fish

Artificial reef – a manmade imitation of a natural reef created by placing hard structures on the sea floor for the purpose of enhancing fish habitat and/or fisheries

ASMFC – Atlantic States Marine Fisheries Commission

Compliance Monitoring – investigations conducted to determine if a reef conforms to the Constitutions mandated by the ACOE permits

DEP – New Jersey Department of Environmental Protection

DGPS – Differentially – corrected Global Positioning System; an electronic navigation device that operates off satellites signals

EFH – Essential Fish Habitat, areas of the marine environment essential for various life stages of federally managed fish and shellfish

EPA – United States Environmental Protection Agency

FMP – a Fishery Management Plan developed by fisheries councils to manage and regulate specific fisheries

Footprint – the area of sea floor covered by reef structures

Fouling Community – See Turf Community

GSMFC – Gulf States Marine Fishery Council

Hang – an obstruction on the ocean bottom that can snag fish nets

Hard-substrate habitat – a firm, stable substrate, such as rock, concrete or a ship's hull, on the sea floor, which is commonly referred to as

reef habitat; as opposed to a sand or mud substrate, which is soft, unconsolidated and subject to shifting

LORAN – Long-range aid to navigation; an electronic navigation device

MAFMC – Mid-Atlantic Fishery Management Council

Micro-reef – a very small (about one cubic yard) reef or reef unit that is isolated from other larger reef structures.

MPA – Marine Protected Area, an ocean sanctuary where fishing is prohibited

MSFCMA – Magnuson – Stevens Fishery Conservation and Management Act

NMFS – National Marine Fisheries Service

NOAA – National Oceanic and Atmospheric Administration

NOS – National Ocean Survey

Patch reef – a several-square yard to several-acre reef constructed by either placing a single structure, such as a ship, or a barge load of material on the sea floor

Performance Monitoring - investigations conducted to determine if a reef meets the biological and socio-economic goals of the program

Pot-day – a measurement of commercial fishing effort that equals a fish or lobster pot set for one day

Profile – the height or relief of a reef structure above the sea floor

PSMFC – Pacific States Marine Fishery Council

Reef Network – all of the reef sites off New Jersey

Reef Site – a large area of the sea floor that is permitted by the ACOE to a permittee for the purpose of building reefs

Reef Unit – a single, fabricated reef structure, such as a concrete-ballasted tire unit or a reef ball

Relief – see profile

SMZ – Special Management Zone; a designation for a reef site granted to a reef permittee by a federal fisheries management council to restrict specified types of fishing gear on that reef site

TRAC – Technical Reef Advisory Committee, will be assembled to evaluate reef materials

Turf Community -the fauna and flora that attach to hard substrates in the sea

USCG – United States Coast Guard